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# A D F

Agriculture Development Fund

# FINAL REPORT

## VALUE ADDED FLAX FIBER AND HEMP FIBER R&D STRATEGIC PLAN FOR SASKATCHEWAN

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# Flax Fiber 2005: A Research and Development Strategic Plan to Capture more of the Added Value Potential of Flax Fiber in Saskatchewan

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Document

Prepared by

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# Abstract

The broad objectives of this study were to develop a strategic plan that could be followed to support the development of flax and hemp fiber based industries in Saskatchewan. To reach this objective, the consultants developed market overviews of the various existing and possible markets for flax and hemp fibers, visited natural fiber research centers, existing processors, brokers and end-users of flax and hemp fibers and attended conferences dealing with natural fibers. The knowledge gained while carrying out these activities was combined with information on the present state of the industry here in Western Canada to develop and set priorities for a series of research and development activities that should be funded and carried out to maximize the flax fiber based value added activities that can be carried out in the province.

# Flax Fiber 2005:
# A Research and Development Strategic Plan to Capture more of the Added Value Potential of Flax Fiber in Saskatchewan

## Executive Summary

### Goals and Opportunities

*We need to be leaders and visionaries with new ideas, new research facilities, new products and new processing plants to help create a vibrant, dynamic, profitable agricultural economy in Saskatchewan.*

The development of flax fiber based industries in Saskatchewan has great potential to create the kind of rural value added activities that we are looking for.

To fully capitalize on the opportunities that exist in the world's natural fiber sector, we must carry out some basic and applied R & D activities to build and enhance the production, processing and marketing opportunities that exist here and outside the province.

This strategic plan lays out the framework, but not specific workplans, for the basic and applied R & D work that needs to be done to help us in Saskatchewan profitably capture these opportunities.

### The Past

In the Northern Plains of North America farmers have concentrated on producing seed from flax. This has been due to several factors:

1. When the Northern Plains were settled, there was a high market demand for linseed oil based products because synthetic oil based products were in their market and product infancy.

2. When the Northern Plains were settled, the demand for flax fibers in clothing (i.e., linen)[1] was declining because of the cheapness of cotton and the relatively high cost of linen due to the fact that little research had been carried out to find ways to reduce the labor and cost of producing high quality flax fiber and linen fabric;

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[1] Traditionally "linen" meant the yarn and fabric produced from flax fibers; however, in the last century in North America linen has also come to mean any textile materials that are used in bedrooms and kitchens.

3. Large scale mechanization of prairie agriculture favored the production of flax for seed because the same machinery used for cereal crops could be used to produce and harvest a seed crop of flax;

4. There were few fiber based industries in this region and hence little lobbying effort for public R & D to be done in the area of fiber flax production or utilization;

5. There was a belief that flax could not "ret" properly under the dry autumn conditions generally found in Western Canada. (The "retting" process refers to the rotting of flax straw to the point where the fibers can be easily separated from the non-fiber portions of the straw. If sufficient retting does not take place, high quality fibers cannot be produced in a cost-effective manner); and

6. There has been little or no exposure to fiber based industries in Western Canada and hence little knowledge of the value-adding potential in this sub-sector of agriculture and industry.

## New Developments and Opportunities for Flax Fibers in Western Canada

Given the above factors, it is understandable that farmers would have concentrated all their efforts on growing flax for seed. However, circumstances and markets are changing. Some of these changes include the fact that:

1. There is a growing trend back to natural fibers for industrial uses. The volume of natural fibers used in non-traditional end-uses is growing particularly fast (i.e., 50% + annually) in Western Europe where companies are now using flax, hemp, sisal and jute fibers to replace the glass fibers (i.e., fiberglass) used in many plastic composites, particularly for those used in the automotive sector. This trend is just beginning to spread to North America and East Asia;

2. There is a growing trend back to natural fibers for clothing. The latest class of French and German drafting and spinning equipment can now produce linen yarn that is even enough to be knitted. This new development permits the production of linen knitwear that is cooler and more comfortable than cotton and that does not wrinkle like traditional linen. Chemical "finishes" have also been developed for woven linen to reduce wrinkling similar to those developed for men's wrinkle-free cotton pants. Since knitting and chemical finishes reduce wrinkling, they will have a very positive effect on re-creating a demand for linen clothing, something that is both more comfortable and more environmentally friendly than cotton clothing;

3. Non-mechanical technologies are being developed that will allow flax fibers to be "cottonized" more cost effectively than the present mechanical systems in use. When flax fibers are cottonized it makes it possible to easily blend and spin them with other fibers on the 90% of the world's spinning and weaving systems which are based on "the cotton system" (i.e., unless long flax fibers are cottonized they cannot be spun on

90% of the world's spinning equipment). Blending cottonized flax fiber with other fibers would be attractive because of the enhanced comfort and environmental friendliness it can give to garments. The market for raw cotton fiber is about 20 million tonnes per year and is growing by about 200,000 tonnes per year. Since cotton is worth roughly US$1,500 per tonne, if cottonized flax could capture eventually capture as little as 5% of the market, it would represent roughly US$1.5 billion dollars annually in raw fiber sales;

4. Recent research in plots and full size fields has shown that flax can be retted successfully in Western Canada at quite low cost providing farmers are given incentives to carry out the field operations that are necessary to ensure good retting. This opens up the possibility to produce fiber for not only higher end industrial uses but also for the high priced textile market;

5. Mechanical systems to handle flax straw with a high fiber content have been developed in Europe and Russia. Relative to historical methods, these mechanical systems require little labor and can be adapted for Western Canadian conditions;

6. Recent research has shown that the costs to produce textile quality flax fiber in Western Canada can be much lower than in Western Europe because of our much lower land costs. Our large scale machinery, large field sizes and cool summer weather can also give us an advantage over smaller farmers located in Eastern North America. The use of high compression fiber balers commonly used for cotton and synthetic fibers would help minimize the transport disadvantage we face relative to flax produced near coastal areas;

7. New companies in Saskatchewan, such as DuraFibre, Nuform, Urban Forest Recyclers and Alpha Fibers have developed, or are developing, improved technologies to salvage and process existing flax straw to provide base materials for novel industrial uses. This is only the start since farm incomes from flax straw and added value processing can be expanded many times over if we actually set out to try and maximize the value we can get out of the flax straw we grow;

8. Across Western Canada, special interest groups are lobbying for legislation to stop the burning of agricultural residues, including flax straw; and

9. The Saskatchewan Flax Development Commission was established in 1996 and represents Saskatchewan flax producers. This farmer-based organization is supporting research and extension activities to reduce flax straw burning and to create new production and value-adding opportunities for its members, whether it is producing flax seed or flax straw and fiber.

## Constraints to Developing These Opportunities

Although there are potentially large and growing markets for fibers from flax grown and processed in Saskatchewan, there are numerous constraints. These include:

1. Lack of knowledge, vision and determination on the part of most private companies, farmers, government officials and academics to seize to potential that exists in the areas of natural fibers;
2. No natural fiber "champion" that is collecting and disseminating information on the potential of flax fiber based activities and that is pushing for the public research that is needed to support the development of more flax fiber based industries in the province;
3. No natural fiber R & D center in Canada;
4. Lack of protocols, facilities, devices and personnel to measure the quality characteristics of flax straw and flax fiber;
5. Limited experience in designing and operating equipment for cost effectively breaking, cleaning and sorting flax straw and fiber;
6. Poor communications and/or attitudes between flax farmers and existing processors;
7. Higher transport costs relative to coastal areas;
8. Few fiber related businesses in the province and lack of local investors who know anything about fibers and/or are willing to take a chance investing in fiber processing facilities;
9. Little or no knowledge on the part of fiber-based companies outside Saskatchewan on the potential for fiber production in Saskatchewan; and
10. No generic R & D promotion of flax fibers for new potential uses.

## What Needs to be Done to Remove These Constraints

To remove the above-mentioned constraints, we recommend the following projects be implemented with priority being given to the projects at the beginning of the following list (details are supplied in the main report).

1. Creation of a provincial Fiber Specialist/Champion Position;
2. Development of quality measurement systems for flax Straw, fiber and shives;
3. Development of improved and/or alternative processing technologies;
4. Implementation of agronomic research in reference to increasing fiber yields and/or quality;
5. Development of new and/or modified products using flax fibers;

6. Investigation and testing of alternative transport and compression technologies; and
7. Promotion of flax fiber based products.

Our first priority project, that of a flax fiber specialist/champion, is important because it helps mobilize resources to work on the next three projects. The second priority project, that of developing systems to measure quality, is important because it gives us the tools and methods to determine where we are in terms of quality and if the activities carried out as part of processing and agronomic trials are helping us reach the quality requirements of various end-uses.

## The On-Going Nature of a Strategic Plan

The reader should keep in mind that a strategic plan is a moving target, especially when the industry is so new as it is with flax fiber in Western Canada. As the plan is implemented new knowledge is collected and discovered; end-use markets emerge, grow or shrink; investors come or leave the sector, industry priorities change, etc. All of these factors influence how the strategic plan should evolve to maximize the potential of the sector. Thus the strategic plan and priorities we have proposed should be periodically reviewed, updated and/or modified.

## Achieving Goals and Capturing Opportunities

***We have a new opportunity to be leaders and visionaries with new ideas, new research facilities, new products and new processing plants that will help develop more rural-based added value industries in Saskatchewan.***

**Immediate funding of a variety of flax fiber-based research and development activities is required to help seize this new opportunity and realize our goal of having a more vibrant, dynamic, profitable agricultural economy in Saskatchewan.**

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# Flax Fiber 2005:
# A Research and Development Strategic Plan to Capture more of the Added Value Potential of Flax Fiber in Saskatchewan

## Mission Statement

*To conduct research and development activities that will improve the value added potential of producing and processing flax fiber.*

## Vision Statement

*To have a wide spectrum of production and processing systems and facilities that profitably take flax straw and transform it into a wide range of fiber types and/or value added products.*

## Introduction

These are both interesting and difficult times for crop based agriculture on the Canadian prairies. While total physical production of crops slowly climbs, prices of traditional seed crops like wheat and barley continue to fall in inflation adjusted terms. Farmers, commodity associations, academics and governments are continually looking for new crops to produce on Western Canada's huge land base. With this in mind, Canada has recently become one of the world leaders in production of such non-traditional seed crops as mustard, canary seed, lentil and field pea.

Although the search for new crops has concentrated very much on crops that produce seeds that can be sold, there have been some efforts made at looking at the production and harvest of non-seed parts (e.g., roots, leaves). However, very little research and development work has been carried out in Canada in the area of agricultural fiber. We know that crop selection and plant genetics can be modified to increase fiber yield of plants. Many say, and we agree, that the mindset needs to change from grain production to the production of grain and fiber per unit area. The research strategy presented in this document begins to address this issue by briefly describing the potential that exists to produce and sell fiber produced from flax. Much of what is written also applies to hemp, a "re-discovered" crop that could, like flax, offer an alternative to totally seed oriented crops. After briefly looking at potential markets, this document points out the barriers that are limiting the ability to develop and capture potential markets. This is followed by a listing and brief description of research projects that would be needed to help remove these constraints. Funding for R&D activities is almost always limited and hence priorities need to be set as to which R&D activities should be funded first. Several possible criteria for setting priorities are set out along with supporting reasons for the highest priority projects.

The research needs of potential flax and hemp fiber based industries in Western Canada are multi-faceted and hence a variety of institutions and companies will be needed to carry out the R&D work and/or to provide funding. Funding possibilities are explored later in this document and public fiber R&D institutions are listed in Appendix A.

Funds to produce this document were provided for by the Agricultural Development Fund of Saskatchewan Agriculture and Food and the Saskatchewan Flax Development Commission. In the course of gathering background material for this report and for the Board members of the Commission, a trip was taken by Linda Braun and Alvin Ulrich to the semi-annual Textiles and Fibers Committee meeting of the American Society for Testing and Materials (ASTM). The ASTM is one of the major groupings in the world that sets standards[2] for a wide variety of materials. Recently ASTM struck a new sub-committee to try and begin setting some standards for flax fiber. This meeting was held in Fort Lauderdale, Florida in October, 1999 and after the meeting Ms. Braun and Mr. Ulrich went on to visit several flax and textile related research and processing facilities in Georgia and South Carolina. Ms. Braun also attended ASTM meetings in March of the following year in Charlotte, North Carolina. A brief report of these trips can be found in the Appendices.[3] Alvin Ulrich and two Saskatchewan Flax Development Commission Directors, Chris Hale and Terry Boehm, were also able to travel to Europe to visit a variety of flax and hemp fiber oriented research centers, processing plants and fiber brokerage companies. A report of this trip can be found in the Appendix.

## Where are we now?

From 1989 to 1998 the area seeded to all annual crops in Western Canada has varied between 27 and 29 million hectares. Of this total, oilseed flax occupied from 0.25 to 0.87 million hectares or roughly two percent of the total cropped area. Most flax is grown in the black soil zones of Eastern Saskatchewan and Southern Manitoba where it competes with crops like wheat, canola, barley, peas and oats. Flax thrives in areas that have relatively few hot summer days (i.e., it does not thrive if the temperature is >28° Celsius), relatively high rainfall, soils which have neither a high percentage of sand or clay, and a growing season of 100 to 120 days. These conditions can be found in many parts of the black, gray and dark brown soil zones. In addition, plant breeders are developing flax varieties suited to other agricultural regions of the province and hence flax acreage could expand several times over and still not encounter land or climatic constraints.

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[2] In ASTM terminology, a "standard" is anything that is agreed upon by ASTM members and published and includes standard definitions, guides, procedures and test methods. ASTM does not set criteria for grading systems although it does publish test methods that could be used by industry to rank a sample of material according to the properties that have been tested using ASTM test methods.

[3] After this document was drafted, Mr. Ulrich and/or Ms. Braun attended other flax fiber and ASTM related meetings. Travel reports concerning these trips can be obtained from the Saskatchewan flax Development Commission.

Almost all the flax grown in Western Canada is oilseed or linseed flax. This type of flax has been bred to have short branched stalks that produce relatively high amounts of seed under Western Canadian conditions. No attention has been paid to the quantity or quality of fiber that is naturally present in flax stems. This is in contrast to many other flax growing regions of the world[4] where tall unbranched flax varieties are bred mainly for fiber and the seed is considered a by-product. Such tall high fiber content varieties are referred to as fiber flax to differentiate them from the oilseed varieties[5]

In Western Canada the concentration on growing flax only for seed is based on several factors:

1) Historically, when Western Canada was settled there was a high demand for linseed oil based paints, which are produced from crushed flax seed. Flaxseed could be produced quite easily with the field equipment of the time and relatively little labor was required. This was unlike the demand for pure linen, which was decreasing at that time due to the abundance of cheap cotton clothing. The production of fiber from flax was also very labor intensive and labor was in relatively short supply in Western Canada;

2) Large scale mechanization of prairie agriculture has favored the continued emphasis on producing flax for seed since the same machinery used to plant and harvest cereal crops can be used for planting and harvesting flax for seed;

3) There has been very few flax fiber based industries developed in Western Canada and historically they have not lobbied for public R&D work to be done in the area of fiber flax production or utilization;

4) There has been a belief among many researchers, farmers and government officials that the climatic conditions in Western Canada are too dry to permit flax straw to "ret". This retting process refers to the rotting of the straw sufficiently so that the fibers can be easily separated from the non-fiber portions of the straw. If sufficient retting does not take place, high quality fibers cannot be produced in a cost-effective manner; and

5) There has been little exposure to fiber industries among the vast majority of people in Western Canada and hence, little knowledge of the value-adding

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[4] The major fiber flax growing areas of the world are found in parts of Russia, China, Ukraine, France, Belgium, Holland, Egypt and Eastern Europe.

[5] In Europe, non-fiber flax varieties are referred to as linseed flax, whereas in North America such varieties are referred to as oilseed flax.

potential in this sub-sector of agriculture and industry. This, in turn, has led to little or no R&D in this field.

## What has changed?

Given the above mentioned factors which have influenced the concentration on oilseed flax, the reader may wonder what has changed to make us now consider producing and processing flax fiber as an industry. This is a valid question; the following may help answer this question.

1) Synthetic oils from hydrocarbons and modified oil products from soybeans have replaced linseed oil as a base for paints, printing inks and floor coverings. The remaining industrial markets for linseed oil are stable or are growing very slowly. Newly developing markets in human and animal nutrition products may take up some of the market for flax seed lost on the industrial side. Flax varieties have recently been developed which have low linolenic acid levels and hence produce a linseed oil that has an extended shelf life. This may open a vast new market for linseed oil as an edible oil product with properties similar to sunflower oil. From a farmer's point of view, one of the major disadvantages of growing linseed flax is "the straw problem". The fiber content of existing linseed varieties is still high enough that the flax straw produced on many fields cannot be easily worked into the soil with field equipment and hence is burnt instead. This creates extra work for farmers and unwelcome air pollution;

2) Mechanical systems to handle flax straw with high fiber content have been developed in Europe and Russia. Relative to historical methods, these mechanical systems require little labor (although they still require more labor than growing oilseed flax);

3) Fiber based and fiber using industries have continued to proliferate in areas of the world that are accustomed to using fibers (e.g., South East Asia, Northwest France). These generally include areas that, at one time or the other, concentrated on spinning cotton, wool, silk or flax. Fibers are now used in a wide range of products in addition to textiles (e.g., insulation, brake pads, artificial wood, automotive dashboards, disposable diapers, etc.). These present new end use possibilities for flax fibers even if the flax straw is not well retted;

4) Retting trials by Biolin Research Inc. of Saskatoon and Ken Domier of Edmonton have shown that flax can be retted successfully in Western Canada, under certain agronomic and climatic conditions. The provision of these conditions is neither expensive nor technically difficult providing the knowledge and suitable incentives are given to farmers. This opens up the possibility to grow flax fiber for not only for higher end industrial uses but also for textile use;

5) It is becoming increasingly easier and cheaper in inflation adjusted terms to travel to and from fiber oriented manufacturing areas of the world and gather information about potential markets, prices and value-added potential. These factors have helped some people, including the authors of this document, to realize that Western Canada is missing out on the potential to create a great deal of value-added businesses based on the production of flax and hemp fiber at the farm level;

6) There is a growing trend back to natural fibers, both in textiles and in certain industrial applications. In the textiles market, higher income consumers are, more and more, placing comfort over easy care and durability. This means a reassurance in the use of cotton, linen, ramie, silk, and hemp and particularly for garments and fabrics made from such fibers that have new easy care characteristics built into them (e.g., a resin finish which makes cotton pants almost wrinkle free). Increasing numbers of linen garments are being knitted or treated with a resin finish to minimize wrinkling. Linen fibers are also now often blended with cotton, rayon, or polyester to reduce wrinkling and cost but still have enhanced levels of comfort relative to pure cotton, rayon or polyester. These trends are likely to significantly increase the demand for linen content textiles in the future;

7) On the industrial side, consumer groups are pressuring companies to produce products that are easier to re-cycle or decompose and for vehicles that are lighter in weight so they have improved gas mileage. This trend is growing particularly fast in Western Europe where companies are now producing flax and hemp fiber based insulation to replace fiberglass insulation in buildings and flax, hemp, sisal and jute fibers are being used to replace the fiberglass now used in many plastic composites, particularly for those used in the automotive sector. Such products made from natural fibers are proving to be not only more environmentally friendly but also lighter in weight. Depending on the end-use they may or may not increase the cost of the end-product relative to one using glass fiber but as the technology and scale of industries using natural fibers increase unit cost of end products using natural fibers are expected to drop significantly. This will further increase the demand for flax fiber;

8) Commercial entities such as DuraFibre, Nuform and Urban Forest Recyclers in Saskatchewan have recognized the value of flax straw and have/are developing process technologies to handle straw and provide base materials for automotive, industrial and packaging applications. These firms are utilizing straw as furnished now by current agronomic practices;

9) Across western Canada special interest groups are lobbying for legislation to stop agricultural residue burning. Manitoba already has such legislation and for the past two years Saskatchewan Agriculture and Food and interested organizations have been working to reduce stubble burning. Special interest groups are becoming frustrated with the time frame and may push harder to regulate or pass legislation to severely limit agricultural residue burning in Saskatchewan; and

10) The Saskatchewan Flax Development Commission was established in 1996 and represents Saskatchewan flax producers. Though a system of mandatory but refundable levy collection ($1.18 per tonne of seed and $0.50 per tonne of straw) the Commission supports activities which will further industry development. The Saskatchewan Flax Development Commission recognizes the challenge of flax straw residue for producers and is supporting research and extension activities to resolve the issue of straw management.

## Types of Flax Fibers and Markets

There is a wide spectrum of semi-processed products that can be produced from flax straw. Appendix B contains a brief description of these as well as the possible size of the market, the approximate prices that will likely be paid and other points that should be taken into account. These market possibilities have been broken into several broad categories and should certainly not be considered as a substitute for the extensive market studies that have been done or should be done; rather they are presented to give the reader a quick overview and opportunity to gain understanding of the potential promises and problems that may present themselves if we move toward developing agricultural fiber oriented industries.

Appendix B presents potential market categories in two ways. The first considers market segments on the basis of final products that can be produced with flax fiber (e.g., textiles, plastic composites); the second considers market segments on the basis of the types of flax fiber that can be produced (e.g., long line, breaker tow). Different end users have inherent maximum prices they can afford to pay for raw fibers as well as different minimum quality requirements for the raw fiber. There is often some overlap between the type of raw fiber that can be used and the ultimate end uses it can be put to (e.g., better quality scutching tow can be "re-scutched" to raise the quality so it can be used in higher value textile applications instead of lower value paper applications.

## Where could we be?

No country or region has exactly the same resource endowment and weather patterns as Saskatchewan and thus one can only search for situations around the world that may bear similarities to past or future situations in Saskatchewan. In the case of flax fiber we might look at the cotton industry in the USA or the fiber flax industry in France for some ideas about what flax fiber based industries may look like in the future.

Both France and the USA have high standards of living, high wages in the agricultural and fiber processing sectors and large and sophisticated agricultural sectors. In this way both countries are similar to Saskatchewan. However, we can find many differences. Both France and the USA have large and sophisticated fiber based industries based partly on natural fibers and partly on synthetic fibers. In Saskatchewan there are very few fiber based industries and those that exist are relatively unsophisticated. Both France and the USA are large producers and exporters of raw fibers but they also have a wide spectrum of fiber based industries which turn domestically produced fiber into semi-finished (e.g., combed sliver, padding) and finished goods (e.g., garments, brake pads, furnace filters). In Saskatchewan the only fiber produced is relatively small amounts of roughly clean flax fiber (e.g., <100,000 t) which is shipped to North Carolina, New Jersey and New York and used in making specialty paper, plastic composite automotive parts and some construction materials. There are also several quilt, sleeping bag, rope and garment makers in the province but these use fibers (largely synthetic) sourced from outside the province.

Has Saskatchewan missed anything by having almost no fiber-based industries? The reader might consider the following examples. The largest privately operated fiber flax processing mill in France contracts and buys 25,000 to 30,000 tonnes of straw and seed from 10,000 acres of fiber flax each year. When the bales of intact (i.e., with seed bolls attached) dry retted flax stalks are brought into the processing plant they are processed to produce:

1) "long line" fiber for use in manufacturing pure linen;

2) good quality "tow" or short fiber for producing coarser yarns and for use in cottonizing;

3) poor quality tow for use in specialty paper;

4) seed for crushing for linseed oil, and

5) shives for use in particleboard and bedding.

All of these products are sold directly except for the best quality tow which is cottonized for blending in yarns and the mid quality tow which is processed into mats that can be used in the manufacture of automotive parts. In spite of the fact that this factory sells only semi-finished goods, it has gross sales of 25 million dollars annually and has 120 full time employees. When we divide the gross sales and full time jobs by the 10,000 acres of flax crop, we find that this flax-processing mill is generating gross sales of $2,500 per acre and one full time job for every 83 acres! This plant is quite automated and the plant must pay employees a salary and benefit package similar to that paid buy many Saskatchewan factories; hence critics cannot say such a fiber based facility exists only because of cheap labor.[6] In contrast, in Saskatchewan, 10,000 acres of oilseed flax is worth roughly $160/acre or $1,600,000 in total and may create, at most, maybe the equivalent of one quarter of a full time job if we add up all the time taken by truckers, elevator agents, railway and part time workers to move roughly 250,000 bushels of flaxseed to port from Saskatchewan.

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[6] Flax farmers in the EU do receive a subsidy to grow both fiber flax and linseed flax, however, this subsidy is needed to counterbalance the subsidies farmers receive for growing cereals and other crops. The value of the flax crop to the above firm reflects the market value it sells its products for and does not include any subsidies that go to farmers.

Another example worth noting is North Carolina. This state is the heartland of fiber based industries in the USA. The basis for these industries started over 200 years ago when North Carolina was one of the most important cotton growing states. Now most American cotton is grown outside the state and cotton is only one of many fibers which is processed and transformed within the state. A quick glance through a directory of textile mills, dyers, finishers and converters shows over 1,100 establishments in the state that turn out a wide spectrum of products ranging from lingerie to curtains to tampons, brake pads to fire hose, acoustical tiles to anti-radar fabric, sailcloth to wiping rags, upholstery fabrics to sportswear, and so on. It is common for such plants to employ from 50 to 100 employees with larger facilities employing several thousand. If each plant averages only 75 employees there would be over 80,000 direct employees and this does not include the hundreds of additional firms which produce fiber processing equipment, spare parts, packaging materials and so forth. Many billions of dollars of fiber based product sales are generated each year in North Carolina with many fiber based products unheard of fifty years ago. In Saskatchewan, fiber based industries are few and probably have total sales of less than 20 million annually. Saskatchewan does face relatively high transportation costs to major centers of fiber consumption but farmland prices here are considerably less than in most major fiber producing regions of the world.

It is worth noting that the USA produces roughly four million tonnes of raw cotton annually out of a world total of roughly 20 million tonnes. Cotton acreage in the USA occupies about two percent of the total agricultural area of the USA. At a long term average price of US$0.70/lb, the average value of the American cotton crop is about US$6.0 billion annually; or roughly equal to the value of all the wheat grown in Canada annually. Several groups have estimated that the 40-50% of the cotton crop processed in the USA results in added value activity in the USA approaching US$30-40 billion annually.

While the above examples are extremely simplistic and ignore a host of historical and technical factors that will prevent Saskatchewan from becoming another French Flanders or North Carolina; Saskatchewan does have very significant unexploited potential in the field of natural fibers, particularly in comparison to other new agricultural products that the province is pursuing.

In the future, if the existing constraints to fiber development are overcome, there are good reasons to believe that Saskatchewan will see dozens of relatively small primary straw processing plants situated close to concentrations of flax fields. Farmers will grow oilseed flax for both industrial and human consumption end uses. Flax straw processing plants will pay incentives to farmers to modify their cultural practices to enhance the quantity and quality of straw that is produced (e.g., plant varieties that have enhanced fiber content, use higher seeding rates, etc.). Some farmers will also plant fiber flax varieties and manage their fields in ways that will allow the fiber thus produced to be sold into higher priced textile and specialty composite applications. These farmers will spend considerably more time and money on their fiber crops than they will on their oilseed flax crops but will also earn considerably more in much the same way as an irrigation farmer can earn considerably more money growing potatoes than he can growing wheat.

Straw processing plants will sell fibers and shives that have a wide range of properties and end uses. There will be industry accepted and government approved methods to measure various properties of fibers and shives. This will improve the purchasing of straw and marketing of fibers and allow processors to produce more consistent lots of fiber. Some fiber will be exported without further processing just as a portion of the American cotton crop is directly exported; however, much of the fiber will be processed in Saskatchewan into some semi-finished and finished products that could range from insulation batts, plastic composite items (e.g., artificial wood, sewer pipes, car parts), pure linen sliver for spinning into linen yarn, bales of cottonized flax for blending with other fibers, specialty pulp, short life time wipes, absorbent core material for hygiene products, compressed horticultural materials and supplies, high end animal litter, etc. Plants producing such items would not only add considerable value to the raw fiber; they would also create a considerable number of jobs in rural areas just as they have in Northern France and North Carolina.

## The Need for Research

In summary, conditions, knowledge and technology have changed significantly both locally and abroad in regard to the possible production and utilization of flax and hemp fibers in Western Canada. The extraction and processing of fiber from the existing flax straw residue as well as the dedicated planting of fiber flax and hemp crops for fiber production now have the potential for added value activities like they never had before. However before this can happen we must overcome the barriers that exist to natural fiber oriented production, processing and manufacturing activities. These barriers and constraints can, we believe, be reduced or removed. Research in the technical, financial and market areas is one of the best ways to meet this goal. Advances in these areas will help instill investor confidence and change attitudes in a positive manner. This, will, in turn, encourage the production and processing of raw fiber which will, in turn, lead to more added value manufacturers using flax and hemp fibers. Thus, one of the main keys to encouraging fiber-based industries is to carry out sufficient technical, financial and market research and development to reach a critical take-off point.

## Constraints, Goals & Objectives

### Constraints

Although there are potentially large and growing markets for fibers from flax and hemp, and the potential exists to grow, extract and add value to these fibers in Saskatchewan, there are numerous constraints to realizing this potential. These may, in order of importance, include:

1) Lack of knowledge, vision, determination and/or the existence of conservative attitudes on the part of most farmers, private companies, government officials and academics;

2) No "champion" (i.e., industry association, company or individual) that is collecting and disseminating information to the public and private sectors on the potential of flax fiber based valued added activities and that is pushing for the public research that is needed for the broad development of fiber based industries in the province;

3) No natural fiber R & D center in Canada;

4) Lack of protocols, facilities, devices and personnel to measure the quality characteristics of flax straw and flax fiber. (This is necessary to: (a) measure the effect of various "treatments" on straw quantity and quality; (b) ensure fairness and reflect true value when buying and selling straw and fiber; (c) permit the most cost effective way to process straw from a given field for a given use; and (d) allow the effective blending of differing lots of straw and fiber to provide larger, homogeneous lots for processing and sale.);

5) Lack of knowledge about the minimum quality and quantity requirements of end-users, competing fibers, processing possibilities; and the relationships between agronomic and processing practices and quality and quantity of fiber produced;

6) Limited experience in designing and operating equipment for cost effective flax straw breaking, cleaning, sorting and baling operations;

7) Poor communication and/or attitudes between producers and processors (i.e., at present, processors want to pay as little as possible for straw so farmers feel they are getting underpaid for the intrinsic value of the fiber contained in the straw). These philosophical differences which will escalate and clash unless industry and farmers communicate and cooperate to develop purchasing systems that reflect the fair value of the straw to all the parties concerned;

8) Relatively high transportation costs to major areas of fiber consumption;

9) Few fiber related businesses in the province and lack of local investors who know anything about fibers and/or are willing to take a chance investing in fiber processing facilities;

10) Little or no knowledge on the part of fiber-based companies outside Saskatchewan on the potential for fiber production in Saskatchewan; and

11) No generic R & D or promotion of flax and hemp fibers for new potential uses (i.e., new users often look to a commodity or government body to "stand behind" the promotion of new potential uses).

## Research Areas and Possible Projects

Based on the observations and analysis contained in the previous sections of this report, the following is a list of short and medium term projects that could reduce and/or eliminate the barriers that are keeping Saskatchewan from reaching the full potential of flax fiber based value-added activities. This list is tentative, of course, and can be added to and/or modified as industrial and research activities in this area evolve over time.

1) Support the position of a flax fiber "champion" who can: collect and disseminate information on the potential and problems of flax fiber based production, processing and quality measurement systems; promote the use of existing flax fiber based products and the development of new end-uses; organize funds and assist R&D efforts by different research institutions and groups; and network with flax fiber R&D efforts going on in other parts of the world;

2) Establish standard methods (i.e., protocols, devices and personnel) to test and evaluate the quality characteristics of flax and hemp straw and fibers (e.g., fiber content, trash content, length, strength, fineness, degree of retting, moisture, softness, etc.);

3) Work jointly with flax and hemp straw and fiber testing institutes in China and Russia where there are already national standards to test many of the important attributes of flax and hemp straw and fiber;

4) Coordinate work on developing Canadian standards for flax straw and fiber testing and grading with groups in the USA and Europe that are attempting to develop standard protocols for measuring quality attributes in flax and hemp;

5) Establish a Canadian system of grading of flax and hemp straw and fiber;

6) Conduct market studies which would gather and interact with existing and potential end users on things like performance requirements, pricing points, potential new product developments, etc. of flax and hemp straw and fiber;

7) Design and/or test systems to cost effectively break and clean different types of flax straw, fiber and shives for different end uses (e.g., what is physically possible, what is economically possible);

8) Investigate ways to reduce transport and shipping costs of flax straw and flax fibers;

9) Carry out agronomic trials over a number of years and at a number of locations so that recommendations can be made as to the effect that certain practices have on the quality and quantity of flax and hemp fiber produced;

10) Conduct trials to look at how retting in the field and in controlled conditions can be done in ways that will improve quality of fibers and/or in ways that are faster or cheaper;

11) Investigate ways to modify flax straw and fibers (e.g., genetically, chemically, etc.) to better suit the needs of particular end uses; and

12) Develop and/or technically support the development of modified and/or new end uses for flax and hemp fibers and for flax shives and hemp hurds.

## Research Priorities

We have already described the existing situation in regard to flax fiber in Saskatchewan and potential markets and value added activities that might take place. Most barriers and constraints can be reduced or eliminated with the sufficient expenditures of money, time, effort, ambition and imagination. Of course, one should first question whether on not the long term potential of a new product (or, in this case, a new sub-sector of products) looks sufficiently large and profitable to justify the initial investment of money and effort. In the case of flax fiber development, we feel the answer is a definite "yes." Given this answer, we then need to set a broad long-term goal, followed by a series of more narrowly focused short-term goals. We then need to examine what types of R & D activities or projects would be necessary to remove or reduce the above mentioned constraints and barriers so we can meet the short and long term goals.

In particular, we need to consider the expenditures of effort and funding that are needed in areas not likely to be financed by the private sector because of the "public nature" type of activity. We also need to consider which type of projects need to be funded first so that other types of R&D can be effectively executed later on.

*Possible Criteria for Projects*

Almost every research program has limits on the amount of financing it can obtain and there is no reason to believe this would not be the case with flax fiber research. Hence the need to set priorities as to the areas of R&D that should receive funding first. There are a variety of criteria that could be used to decide which flax fiber related projects should be given priority. Different criteria can lead to a different priority list of R&D projects. In the case of flax fibers on the Prairies, criteria that might be considered when setting priorities could include giving the highest priority to projects that will:

1) benefit the most people in the short run;

2) have the greatest impact on reducing the amount of straw that is burnt;

3) have the potential to add the most value on a per tonne or per acre basis;

4) lead to the largest percentage of locally used end-products;

5) require the least amount of new capital investment on the part of farmers;

6) require the least amount of capital investment in processing facilities;

7) generate the greatest number of jobs in rural areas;

8) produce the greatest volume of sales in the long term (i.e., after ten years); or

9) produce the greatest value of sales in the long term.

In the case of flax fiber development we have barriers in the areas of technology (i.e., agronomy, harvesting, storage, processing, measurement of straw and fiber properties), end product development and marketing, transportation costs, access to public and private investment and lack of fiber oriented knowledge and attitudes.

*Recommended Criteria*
If we assume that public and private funding over a period of time can greatly reduce technical and physical constraints, then we should ask ourselves what are the barriers to funding R&D in the flax fiber area. We believe the answer is lack of fiber-oriented knowledge and attitudes. In other words, most decision makers in charge of funding R&D projects within Saskatchewan have little or no knowledge about the potential value added that could be generated by flax fiber based industries and about the real problems that need to be overcome before this potential can be reached. We thus recommend that fiber-related R & D projects be ranked according to their ability to stimulate industry expansion and further R & D which can stimulate even more industry expansion. In other words, **our goal should be to significantly increase the capacity to process flax straw, flax fiber and shives by an increasing number of firms in Saskatchewan within the next five years.** Hence, priority should be given to projects which will directly or indirectly lead to an increasing number of firms being involved in adding value to flax fibers in a widening spectrum of ways. Priority should also be given to projects which are necessary to develop the industry for a variety of processing companies but which are unlikely to be funded by the private sector because of the "public good" nature of these projects (e.g., agronomic trials, national testing and grading methods).

Short term goals that would help us reach this longer term goal would be to:

1. Change the attitude and knowledge base of sufficient decision makers within and outside the province so that research, development and investment funds are available

to enable the province to start capturing more of the potential of flax fiber value-added activities;

2. Adopt, modify and/or develop systems (i.e., protocols, devices and personnel) to measure quality characteristics of flax straw and flax fiber that are accurate, reliable, cost effective and acceptable to processors and farmers;

3. Carry out a wide variety of technology enhancement and optimization activities that will allow farmers, processors and end-users to reduce their per unit costs and/or to produce more consistent and/or higher quality products made from flax straw, fibers and shives; and

4. Conduct end product and market development work to enhance the market for flax fiber based products.

## *Priority Projects*

Based on the short term goals identified, we recommend priority be given to the following briefly described projects (more complete project descriptions would be completed when funding is sought for each project, in accordance with the requirements of the funding sources involved). At the end of each priority project we have provided a rough indication of the resources that would be required and the time frame involved. We have also given an indication of where funding would likely come from. It should be noted that public sector funding would include possible funding from commodity based groups like the Saskatchewan Flax Development Commission.

### 1. Creation of a Provincial Fiber Specialist/Champion Position

To change this situation, we need someone who can concentrate on stimulating the resources that are needed to develop the potential of flax fiber based industries in the province. This would include, but not be restricted to:

1. changing the knowledge and attitude base so that funding does become available for flax fiber oriented R&D;
2. helping individuals, groups and institutions source funds, personnel and equipment to successfully carry out R & D projects in the area of flax straw, fibers and shives;
3. initiating and directing R & D projects relevant to flax straw, fiber and shive related projects;
4. collecting, maintaining and disseminating of flax straw, fiber and shive related information (e.g., R&D results here and overseas, market information, developments in complimentary and competitive fibers);
5. working with local, national and international producers, processors and academic centers to develop measuring and grading systems and standards for flax straw, fiber and shives;

6. interacting with foreign processors and end-users of flax straw, fiber and shives to encourage them to set up processing facilities here and/or to use Saskatchewan sourced flax straw, fiber and shives; and
7. encouraging farm groups and/or local investors to build flax fiber based production and processing facilities.

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| Starting Time: | As soon as possible |
| Length of Project: | Indeterminate |
| Personnel: | One enthusiastic person with a wide range of knowledge regarding possible methods of flax fiber production, harvesting, processing and end uses |
| Resources: | Minimal providing it is possible to access a "technical centers" that have measurement and processing capacity |
| Approx. Funding: | $100,000 – 150,000 including funds for office, travel, information collection and dissemination |
| Funding Sources: | Public sector |

**2. Development of Quality Measurement Systems for Flax Straw, Fiber and Shives**
The next highest R&D priority should concern itself funding for equipment, space and personnel to process (i.e., decorticate and clean) and test the properties of flax straw and fiber using protocols adopted and/or modified from flax fiber research centers in other parts of the world or developed here and hopefully accepted by other flax fiber related organizations. Flax straw, fiber and shives have many properties (i.e., strength, fineness, trash content, etc.) which greatly affect the usefulness of a particular batch of straw, fiber or shives in a particular end use and hence greatly affect the commercial value of the raw material in question. Such a testing center should be given a very high priority because standard testing devices and protocols will give results that can be then used to judge the effect that a particular agronomic, harvesting, storage or processing practice or treatment has on the properties of a fiber. In other words, many flax fiber research projects in the future will revolve around finding ways to improve the quantity and quality of fiber produced and/or to lower production and processing costs. This will involve altering the kind and intensity or amount of "treatment" (e.g., amount of nitrogen fertilizer, pressure on processing rollers, retting for a longer period of time, etc.) until the level of treatment is optimized to produce a desired level of a fiber parameter (e.g., fineness, strength, etc.). Thus the implementation and success of such "improvement" type of projects is vitally dependent upon the ability to quantify (i.e., measure) the relationship between a level of treatment and the level of a fiber characteristic. It is for this reason that a project to purchase equipment, space and personnel to adopt and/or develop measurement protocols and then to be available to measure selected properties for a diversity of clients and fiber related projects should be a very high priority. Such a project may evolve into or become part of a natural fiber technology center.

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| Starting Time: | As soon as possible |

Length of Project: Indeterminate
Personnel: One fiber measurement specialist; part-time and/or full-time technicians
Resources: Variety of measuring and small processing equipment inside a lab where humidity and temperature can be controlled
Approx. Funding: $100,000 – 150,000 in first year for equipment; $30,000 – 50,000 per year after that for adding to and/or modifying equipment $90,000 – 100,000 per year for staff, staff travel, etc. (NOTE: it is our understanding that ADF funding for this position in Agricultural and Bioresource Engineering is already in place, at least for one year)
Funding Sources: Public sector; potential private sector funding once project develops

### 3. Development of Improved and/or Alternative Processing Technologies

The next level of priority project should revolve around processing technologies. The decorticating and cleaning of flax straw is an integral step to extracting the fibers from the flax straw. Without fibers we have, in most cases, nothing to sell. If we do not have access to several cost-effective methods of removing the fiber from unretted and retted straw, we will not have new processing industries and/or will not be able to generate cash flow to continue operations. European fiber cleaning technologies tend to be relatively expensive with low capacity. This results in high processing costs per tonne. Chinese and Russian fiber cleaning systems are much cheaper than European systems but require more labor (i.e., a relatively expensive item in Saskatchewan) and are more prone to mechanical breakdown. Many fiber-cleaning systems are too aggressive for over-retted straw and consequently produce an unacceptably high level of short waste fibers. Machinery built to handle fine fibers like cotton may prove to be more suitable for handling fine flax fibers than traditional flax fiber cleaning systems. Different end users (and especially the non-traditional end uses) will require different fiber characteristics (e.g., some end uses may need longer fibers than other end uses); many of which are heavily influenced by the processing system that is used. In recognition of the above-mentioned factors, projects revolving around processing technologies are the third type of priority project.

Starting Time: As and when funding agreements put in place with private sector clients and/or when public funds become available to work on methods that would be made available to the public; whether farmers, processors or end-users
Length of Project: Indeterminate
Personnel: Short term specialists drawn from a variety of institutions and private sector companies; several part-time technicians may be needed; cooperation of fiber testing specialist
Resources: Variety of metal and machinery fabricating facilities would be needed to fabricate and/or modify existing fiber processing

equipment and/or to build pilot scale equipment to test new concepts or modifications

Approx. Funding: Variable depending on resources and perceived needs of processors

Funding Sources: Private and public sector

## 4. Agronomic, Product Development and Transport Research

The fourth level of priority includes projects that involve agronomic, product development and transport research. These important areas of research are needed to support the long-term profitability of the industry and they need partial implementation of the first three projects before they can be really effectively implemented. Of these three types of R & D projects, those involving agronomic work are the least likely to be funded by the private sector and hence should be given a higher priority by public funding agencies than product development or transport related projects.

### *4a. Agronomic Research*

Agronomic practices (i.e., which varieties to plant in which areas, when to plant, how to plant, how to fertilize, etc.) have a great influence on the quantity, quality and ultimate profitability of the straw and fiber that is produced. Since it takes three or more years to be relatively confident of research conclusions in agronomic trials due to the wide range of growing season weather patterns that can be experienced; agronomic trials should be set up as soon as possible so that we will not have to wait four or five years before we can start being confident about recommending certain agronomic practices. Another important reason that agronomic research should be given relatively high priority is that it is a research activity few private companies are willing to finance because of the difficulty of keeping the results private. Hence private companies hesitate to spend money on discovering something that can be easily copied by their competitors with little or no cost involved. Thus most basic agronomic research in Western Canada has always been funded by the public sector. It generated high benefits to society, as a whole, but little funding from private sources will ever be forthcoming from private sources to carry out this type of research.

Starting Time: Spring of 2001

Length of Project: At least three years

Personnel: Existing staff at research stations; extra technician required to collect and test process straw; Short term help and supervision would be required from the fiber specialist/champion and the fiber measurement specialist

Resources: Plot land at three or more locations; seed; crop inputs; plot machinery; straw storage and processing space; access to small sample processing and quality testing devices;

Approx. Funding: $100,000-150,000 per year for agronomic trials
$100,000-500,000 per year depending on how many quality attributes tests carried out on each sample and the type and cost of equipment that is available to do the tests

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| Funding Sources: | Public sector; possibly some private funding |

### *4b. Product Development Research*

Product development projects would include developing new ways to use or incorporate flax straw, fiber and shives into products or to encourage manufacturers to substitute Saskatchewan sourced flax fiber for the glass, synthetic or natural fibers that are presently using. It is important to carry out market development work and to find new end-use markets for flax straw, fiber and shives, however, private companies are more likely to fund these type of projects and there are some existing markets that can absorb new sources of flax fiber and shives for some time to come.

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| Starting Time: | As and when funding agreements put in place with private sector clients |
| Length of Project: | Indeterminate |
| Personnel: | Short term specialists drawn from a variety of institutions and private sector companies; several part-time or full time technicians may be needed in the longer run; cooperation of fiber testing specialist |
| Resources: | Variety of measuring and small processing equipment inside a lab where humidity and temperature can be controlled; access to pilot scale and full scale processing and manufacturing facilities |
| Approx. Funding: | Variable depending on resources and perceived needs of processors |
| Funding Sources: | Private and public sector |

### *4c. Transport Research*

Transport research projects would revolve around trying to reduce the cost of packaging and transporting flax straw, fiber and shives. Flax straw and flax fibers have low bulk densities unless compression takes place. This compression usually takes the form of round bales, small square bales, large square bales, flax tow bales or cotton bales. Compression is necessary to increase the bulk density so that the transport cost to move a given volume of straw or fiber can be minimized. Flax fields in Saskatchewan are often a long way from potential processing plant sites and Saskatchewan is far distant from major fiber using industries. This means that transportation costs are relatively high. Since end users normally do not pay one supplier of fiber more than another supplier (providing the quality is similar), the supplier who lives a long distance from an end-user ultimately receives a lower f.o.b. price than one who lives near by. Thus any improved ways to compress and/or transport flax straw or fiber will have a significant impact on profitability of fiber-based production and processing in Saskatchewan, regardless of the type of fiber or end-use. This type of project is also more likely to be funded by private firms than agronomic research.

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| Starting Time: | As and when funding agreements put in place with private sector clients and/or when public funds become available to work on |

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| | methods that would be made available to the public; whether farmers, processors or end-users |
| Length of Project: | Indeterminate |
| Personnel: | Short term specialists drawn from a variety of institutions and private sector companies; several part-time technicians may be needed; cooperation of fiber testing specialist |
| Resources: | Variety of metal and machinery fabricating facilities would be needed to fabricate and/or modify existing compression based equipment and/or to modify equipment that might be required to re-open the resultant compressed bales of straw or fiber. |
| Approx. Funding: | Variable depending on resources and perceived needs of processors |
| Funding Sources: | Private and public sector |

### The Interdependence of the Proposed Projects

In summary, our first priority project, that of a flax fiber specialist/champion is important because it helps mobilize resources to work on the next three projects. The second priority project, that of developing systems to measure quality, is important because it gives us the tools and methods to determine where we are in terms of quality and if the activities carried out as part of processing and agronomic trials are helping us reach our long term goal. In other words, to make best use of the information generated during processing and agronomic trials, we need to incorporate the systems we develop in the quality measurement projects.

### The On-Going Nature of a Strategic Plan

The reader should keep in mind that a strategic plan is a moving target, especially when the industry is so new as it is with flax fiber in Western Canada. As the plan is implemented new knowledge is collected and discovered; end-use markets emerge, grow or shrink; investors come or leave the sector, industry priorities change, etc. All of these factors influence how the strategic plan should evolve to maximize the potential of the sector. Thus the strategic plan we have proposed should be periodically reviewed, updated and/or modified.

## Potential Research Service Providers

There are a wide variety of institutions doing work with fibers and many of them have worked with natural fibers. A list of several dozen in a variety of countries is shown in Appendix A. This list is not inclusive and does not represent any kind of scoring or priority ranking. It is quite possible that some excellent potential research service providers have been missed. If this is the case, it is because of lack of information and not because of some deliberate effort on the part of the authors. The reader should note that there are only a couple Canadian institutions that have any experience in the processing and/or measurement of natural fibers. Although many of the American institutions have only worked with cotton, there is considerable overlap in some types of measurement, processing and end product development research between cotton, cottonized flax and flax tow and hence we have decided to list these even though they may not have worked with flax. It should also be noted that there are many textile equipment producers and end product manufacturers who have their own in house labs and often do contract research for existing and potential new clients. We have not listed such individual companies since there are many of them but such companies could provide very useful research services for the development of flax fiber related businesses. In some cases (e.g., National Research Council in Saskatoon) we have listed the institution, not because they have experience in fibers but because they are nearby and have some instruments that may be useful for particular types of flax fiber related research.

## Potential Funding Sources

There are several government research funding programs available in Western Canada. These were created to support agricultural and rural economic diversification. Commodity groups, farmer groups, private companies and/or individuals can apply for funding from these government funding sources to carry out R&D work in cooperation with the potential research service providers listed in Appendix A. The following outlines the funding programs that might make money available to carry out flax fiber oriented R&D.

The **Saskatchewan Flax Development Commission** operates a check-off system within Saskatchewan on sales of seed and straw. Funds are allocated to research, member communications, promotion and administration in an attempt to enhance the incomes farmers receive from growing flax. Manitoba flax producers are considering a similar development commission in their province, which may be a future additional source of funding. Research funds are normally given as grants; some financial or in-kind contribution by the proponent is requested.

The **Flax Council of Canada** operates a check-off system based on flax seed that is exported. Funds are largely allocated to promotion of flax seed end uses, communication, lobbying efforts and administration. To date the Council has shown no interest in any research, development or promotion of flax straw or fiber but this may change in the future. Funds are normally given as grants; some financial or in-kind contribution by the proponent is requested.

**Saskatchewan Agriculture and Food** has funded a long list of flax related projects; most receive funding through the Department's **Agricultural Development Fund** (ADF) but some flax related projects have also been funded through the Department's recently created **TAD** program and/or directly through ongoing activities of different sections of the Department. In the last few years, money has been made available for flax fiber related market studies and private technology development. Research funds are normally given as grants; some financial or in-kind contribution by the proponent is generally requested. Funds are also given out through a joint provincial/federal government program called the **Agri-Food Innovation Fund (AFIF)** to assist in the funding expenditures that can not be covered through the IRAP program (see below). These include expenditures for such expense items like marketing, travel and purchase of equipment.

The **National Research Council**, through its **Industrial Research Assistance Program (IRAP)** offers financial assistance to companies who need to find, modify or develop new technologies, processes and products that have the potential to add value to Canadian materials and resources. There are several types of IRAP assistance available but most require a significant financial contribution on the part of the proponent of the project.

Agriculture and Agri-Food Canada (AAFC) provides funding through the **Canadian Adaptation and Rural Development Fund (CARD)** program for an assortment of rural development and rural processing initiatives. Funds from AAFC are also provided for through the **Matching Industry Initiatives (MII)** program administered under the Marketing and Industry Services Branch (MISB) of AAFC.

The **Western Diversification Office (WDO)** provides repayable loans to enterprises seeking to set up or expand in Western Canada with preference being given to non-traditional products and services. Funds are also given on a grant basis to assist infrastructure projects that will help a whole industry or sub-sector develop.

The Saskatchewan Cooperative and Economic Development Department has set up a **Strategic Initiatives Fund** to assist the start-up of new industries.

The **Saskatchewan Ag-Equity Fund** provides 49% or less equity investment in new and/or novel agricultural start-up companies with a pre-implementation agreement on how the other owners can eventually purchase back the equity from the Fund.

The **Manitoba Rural Adaptation Council** offers funding for projects that will all producers and rural agri-business to diversify production and expand value-added processing. Research and development areas of interest to the Council include new technology, sustainable agriculture, product development, risk management and marketing. Up to 100% project funding is available.

The **Alberta Value Added Corporation (AVAC Ltd.)** was established to help increase the value of Alberta value-added agriculture industry. The Corporation operates independently of government or industry and is owned by its fee-paying members. AVAC provides financial investment and collaborative assistance to projects in three areas: a) research and development; 2) the development and commercialization of new products; and c) the long-term growth of the sector. AVAC invests in projects with the expectation of future returns in the form of either royalties, future income streams or interest in intellectual properties.

Many municipalities in the Prairie Provinces have joined together to form **Rural Development Agencies or Authorities** to encourage new or expanded rural based industries in their jurisdictions. They often make tax concessions or build infrastructure like roads, sewer, water and electricity connections to encourage this type of development.

**Canmet Energy Technology Centre (CETC)** located in Nepean, Ontario uses lab facilities to support development of novel combustion and uses cost share arrangements and partnerships to develop technologies to improve energy efficiency within environmentally friendly designs. They have a characterization laboratory as well as an industry energy research and development program. CETC may be a funding source or potential program partner for several sectors (i.e. fuel).

The **Natural Sciences and Engineering Research Council of Canada** (NSERC) may provide equipment grants which foster and enhance the research and research training capability of university researchers by supporting the purchase of research equipment and installations. They also offer opportunities for postgraduate scholarships and offer major facilities access grants to support researchers' access to major regional or national research facilities.

The **Alberta Research Council** (ARC) offers the joint research ventures program which allows the Council to move technology forward into the marketplace. JRVS are the best companies available to develop and commercialize the technology. ARC contributes work in-kind in exchange for sharing the risk, this expects to participate in the associated reward.

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# Appendix A

# Potential Institutions That Could Carry Out Flax Fiber Research

# Appendix A

## Potential Institutions That Could Carry Out Flax Fiber Research

### Canada

**Agriculture and Agri-Food Canada**
Research Branch
AAFC Research Centers/Stations
Various locations
(p) (306) 956-7200

**Alberta Agriculture, Food & Rural Development**
Crop Diversification Centre North
RR 6, 17507 Fort Road
Edmonton, Alberta
T5B 4K3
(p) (780) 422-1789
(f) (780) 422-6096

**Alberta Research Council**
250 Karl Clark Road
Edmonton, Alberta
(p) (780) 450-5418
(f) (403) 450-5397

**Mohawk College of Applied Arts and Technology**
135 Fennell Avenue West
Hamilton, ON L8N 3T2
(p) (905) 575-1212

**National Research Council of Canada**
110 Gymnasium Place
Saskatoon, SK S7N 0W9
(p) (306) 975-5248
(f) (306) 975-4717

**PAMI**
Box 1900
Humboldt, SK
S0K 0K0
(p) (800) 567-7264/(306) 682-2555
(f) (306) 682-5080

**PFRA Demonstration** Farm
901 McKenzie St South
Outlook, Saskatchewan
Canada
S0L 2N0
(p) (306) 867-5400
(f) (306) 867-9656

**POS Pilot Plant Corporation**
118 Veterinary Road
Saskatoon, SK S7N 2R4
(p) (306) 978 2853
(f) (306) 975 3766

**SAGEOS**
Textile Technology Centre
Geosynthetics Technology Centre
3000 Boullé Street
St. Hyacinthe, Quebec J2S 1H9
(p) (450) 771-4608
(f) (450) 778-3901

**Saskatchewan Research Council**
125 - 15 Innovation Drive
Saskatoon, SK
S7N 2X8
(p) (306) 933-7446
(f) (306) 933-5400

**University of Alberta**
Department of Human Ecology
Edmonton, AB T6G 2N1
(p) (780) 492-3111

**University of Saskatchewan**
Agriculture & Bioresource Engineering
51 Campus Drive
Saskatoon, SK S7N 5A8
(p) (306) 966-5310

**University of Saskatchewan**
Crop Development Center
51 Campus Drive
Saskatoon, SK S7N 5A8
(p) (306)966-4946

## United States

**Auburn University**
Department of Textile Engineering
101 Textile Bldg.
Auburn, AL
USA 36849-5327
(p) 334-844-5452

**Clemson University**
School of Textiles, Fiber & Polymer Science
228 McAdams Hall
Clemson, SC
USA 29634-0357
(p) (803) 656-4058/(864) 656-3176
(f) (864) 656-5973

**Georgia Institute of Technology**
School of Textile & Fiber Engineering
Atlanta, GA
USA 30332-0295
(p) (404) 894-2490
(f) (404) 894-8780

**INDA**
Association of the Non-woven Fabrics Industry
1001 Winstead Drive, Suite 460
Cary, NC
USA 27513
(p) (919) 677-0060
(f) (919) 677-0211

**Institute of Textile Technology**
2551 Ivy Rd.
Charlottesville, VA
USA 22903-4614
(p) (804) 296-5511
(f) (804) 977-5400

**MTS - Marketing Technology Service**
MTS Testing Laboratories
4100 S 7th St
Kalamazoo, MI
USA 49009-8461
(p) (616) 375-1236
(f) (616) 375-6710

**North Carolina State University**
P.O. Box 8301
Raleigh, NC
USA 27695
(p) (919) 515-6500
(f) (919) 515-3057

**North Carolina Center for Applied Textile Technology**
7220 Wlkinson Blvd.
P.O. Box 1044
Belmont, NC
USA 28012
(p) (704) 825-3737

**Philadelphia College of Textiles & Science**
School House Lane & Henry Ave.
Philadelphia, PA
USA 19144
(p)(215) 951-2700
(f) (215) 951-2615

**Purdue University**
Textile Science & Apparel Technology
Mathews Hall
West Lafayette, IN
USA 47907
(p) (765) 494-8235

**Richard B. Russell Agricultural Research Center**
905 College Station Road
USDA - Agricultural Research Service
Athens, GA
USA 30605
(p) (706) 546-3482
(f) (706) 546-3607

**Southern Polytechnic State Univ.**
1100 S. Marietta Pkwy
Marietta, GA
USA 30062
(p) (770) 528-3172
(f) (770) 528-7556

**State Institute of New York**
Fashion Institute of Technology
Seventh Ave. at 27th St.
New York, NY
USA 10001-5992
(p) (212) 217-7686

**TAPPI**
P.O. Box 105113
Atlanta, GA
USA 30348-5113
(p) (800) 332-8686 USA
(800) 446-9431 Canada
(f) (770) 446-1400

**Texas Tech University**
International Textile Center
P.O. Box 5888
Lubbock, TX
USA 79408-5888
(p) (806) 747-3790
(f) (806) 747-3796

**Texas Woman's University**
Dept. of Fashion & Textiles
P.O. Box 425529
TWU Station
Denton, TX
USA 76204
(p) (940) 898-2661
(f) (940) 898-2711

**The Forest Products Society**
The Forest Products Institute
2801 Marshall Court
Madison, WI
USA 53705-2295
(p) (608) 231-1361
(f) (608) 231-2152

**University of Georgia**
College of Agricultural and
Environmental Sciences
Conner Hall
Athens, GA
USA 30602 –7509
(p) (706) 542-2481
(f) (706) 542-0739

**University of Massachusetts at Dartmouth**
North Dartmouth, MA
USA 02747
(p) (508) 999-8448

**University of Massachusetts at Lowell**
Lowell, MA
USA 01854
(p) (978) 934-4000

**University of Missouri-Columbia**
Dept. of Textile & Apparel Management
137 Stanley Hall
Columbia, MO
USA 65211
(p) (573) 882-6634

**University of Rhode Island**
Dept. of Textiles, Merchandizing & Design
Kingston, RI
USA 02881-0809
(p) (401) 874-4574
(f) (401) 874-2581

**University of Tennessee**
Textiles & Nonwovens Development Center
1321 White Avenue
Knoxville, TN
USA 37996-1950
(p) (423) 974-6298
(f) (423) 974-3580

## Brazil

**UNESP-Universidade Estadul Paulista**
**SP-18603-970**
Botucatu, Brazil
(p) 5 (514) 821-3883
(f) 5 (514) 821-3438

## Northern Ireland

**The Agricultural Research Institute of Northern Ireland**
Hillsborough, County Down
United Kingdom BT26 6DR
(p) 0 (184) 668-2484
(f) 0 (184) 668-9594

**The Queen's University of Belfast**
Department of Applied Plant Science
School of Agriculture and Food Science
Newforge Lane
Belfast, Northern Ireland
BT9 5PX
(p) 0044 (123) 225-5245/225-5526
(f) 0044 (123) 266-8375

## United Kingdom

**Anglia Polytechnic University**
Department of Life Sciences
School of Applied Sciences
East Road
Cambridge, CB1, 1PT
United Kingdom
(p) 0 (122) 336-3271

**Silsoe Research Institute**
Wrest Park
Silsoe Bedford MK45 4HS
UNITED KINGDOM
(p) 44 (152) 586-0000
(f) 44 (152) 586-0156

## Germany

**Bremen Fibre Institute**
Postfach 10 58 07; 28058 Bremen
Wachtstr. 17-24; 28195
Bremen, Germany
(p) 49 (042) 136-0890
(f) 490 (421) 339-84 99

**Carmen e.v.**
Technologiepark 13
97222
Rimpar, Germany
(p) (093) 658-0690
(f) 0 (936) 580-6955

**FH Ruetlingen**
Institut Fur Angewandte Forschung
Alteburgstrabe 150
Reutlingen, Germany
D-72762
(p) 0 (712) 127-1551
(f) 0 (712) 127-1537

**German Institutes for Textile and Fiber Research**
Institute for Man-Made Fibers
Institute for Textile Chemistry
Körschtalstraße 26, 73770
Denkendorf, Germany
(p) 490 (711) 934-0101
(f) 490 (711) 934-0185

**Institut Fur Agrartechnik Bornim**
(Institute of Agricultural Engineering)
Max-Eyth-Allee 100
D-14469 Potsdam-Bornim
Germany
(p) 49 (331) 569-9310
(f) 49 (331) 569-9849

**University of Kiel**
Olshausenstr. 40, 24098 Kiel
Kiel, Germany
(p) 49 (431) 880-1722
(f) 49 (431) 880-1560

## Poland

**Institute of Natural Fibers**
ul. Wojska Polskiego 71 B
Poznan, Poland
60-630
(p) 48 (061) 848-0061
(f) 48 (061) 841-7830

## Czech Republic

**CLM - Ceskomoravsky len**
Lnarska 499
396 Humpolec
Czech Republic
(p) (03) 675-32314(zazn) (03) 371
(f) (0) 367-2163

## Italy

**Consultative Group on Intl. Agricultural Research (CGIAR)**
Via della Sette Chiese 142
00145 Roma, Italy
(p) (390) 651-8921
(f) 3 (906)575-0309

**Centro Tecnico Industriale IPZS**
Via Carlo Piaggia
160 - Arancio
Lucca - Italia
(p) (058) 395-5503
(f) (058) 395-4334

**Tecnagri**
Via Faentina 106
48100 Ravenna, Italy
500430
(p) 39 (054) 450-0430
(f) 39 (054) 450-0374

## France

**Institut National de la Recherche Agronomique (INRA)**
Laboratoire de Biochimie des
Macromolécules Végétales
Chargé de Recherches
Reims, Champagne
France
(p) 33 (032) 677-3593
(f) 33 (032) 677-3599

**Institut Technique Du Lin**
5, Rue Cardinal Mecier
Paris, France
75009
(p) (14) 280-4056
(f) (14) 526-2427

**Universite de Lille 1**
Laboratoire de Physiologie des Parois
Végétales
UFR de Bioliogie
Ville Neuve, Cedex
France
59655
(p) (032) 833-3634
(f) (032) 833-36 32

## Denmark

**The Danish Agriculture and Advisory Centre**
Department of Plant Production
Udkaersvej 15, DK-8200 Arus N
Denmark
(p) (458) 740-5000
(f) (458) 740-5090

## Belgium

**Algemeen Belgisch Vlasverbond vzw**
Oude Vestingsstraat 15,
Kortrijk, Belgium
B-8500
(p) (325) 622-0261
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**Universiteit Gent**
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Gent, Belgium
(p) (329) 264-5374

## Finland

**Agricultural Research Centre of Finland (MTT)**
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FIN-31600 Jokioinen, Finland
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(p.ho) 35 (897) 085-8499
(f.ag) 35 (897) 085-8491
(f.ho) 35 (897) 085-8686

**University of Kuopio**
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(p) 3 (581) 716-2211

## Russia

**N.I. Vavilov Research Institute of Plant Industry**
42, Bolshaya Morskaya Str.
St. Petersburg, Russia
190000
(p) 7 (812) 314-7836
(f) 7 (812) 311-8762

**The All Russia Flax Institute (VNIIL)**
Lunacharsky str., 35
Torzhok, Russia
172060
(p) 7 (082) 515-1844
(f) 7 (082) 515-4458

## Ukraine

**Institute of Agriculture of Ukrainian**
Academy of Agrarian Sciences
Herojiv Oborony str., 15,
Kyiv, Ukraine, 252041
(p) 38 (044) 263-5175
(f) 38 (044) 263-5175

## China

**Academy of Agricultural Science**
Institute of Industrial Crops
Kangis Town
Hulang County
Heilongjiang, China
150518
(p) 86 (451) 521-1352
(f) 86 (451) 521-1352

**China National Textile Machinery Instrument Corp.**
Changzhou No.2 Textile Instrument Factory
1st Floor, Fang Gong Building
Changzhou, China
213001
(p) (881) 646-0385
(f) 0 (519) 881-4892

**Heilongjiang Provincial Textile Council**
No. 230 Huayuan
Harbin, China 150001
(p) 0 (451) 362-1462
(f) 0 (451) 364-1033

## Hong Kong

**Hong Kong Polytech**
Hung Hom,
Kowloon,Hong Kong
(p) 8 (522) 766-5111
(f) 8 (522) 764-3374

## Egypt

**National Research Centre**
El-Tahir str. Dokki
Cairo, Egypt
(p) (202) 337-7164
(f) (202) 337-0931

# Appendix B

# End Product Market Categories

# Appendix B

## End Product Market Categories

## Pure Linen Textiles

### Market

- Fibers and fabrics derived from flax were traditionally called linen
- Existing linen market 200,000 - 300,000 t/yr. for long and short fibers (i.e., for long line and tow)
- Best quality linen is said to come from Italy and France but biggest volume pure linen producers are the Chinese and Russians
- Pure linen garments are much cooler and absorb more moisture than cotton garments; they can also withstand more washings and are ecologically much more friendly than cotton
- Traditional market was only woven fabrics; these wrinkle easily and hence have lost appeal in many markets because of the need to iron; new developments in knitting technology allow even 100% linen content knit goods to be produced; these have the coolness and comfort of woven linen but do not wrinkle
- Potential linen market in the next five years could grow by 100,000 tonnes if knitted linen goods become more popular

### Type of Raw Fibers Used

- Long line, hackled tow, scutched tow, re-scutched tow

### Technology

- Compared to R&D expenditures for cotton and synthetic fibers, pure linen R&D is miniscule
- Spinning must be done on spinning frames built especially for flax and hemp fibers
- Raw fiber must be hackled (i.e., combed) before fiber can be prepared for spinning; hackling with traditional machines is relatively labor intensive but automated machines are now available

- Traditional spinning and weaving of long line is labor intensive and is usually done where labor is cheap (e.g., China) or where EU policies support the industry (e.g., Ireland)
- France, Belgium, Italy and Ireland appear to be on cutting edge of long line R&D; the Chinese appear to be breaking the most new ground in commercializing new technologies to spin, weave and finish pure linen

## Capital

- $5-50 Million for spinning and weaving mill
- Less costly if used machinery can be purchased

## Competition With

- Spinners and weavers making fabrics from natural fibers like cotton, silk, ramie, hemp
- Linen blend fabrics
- Cotton/synthetic blends that look like linen but have easy care features

## Opportunities

- Promote pure linen as much more ecologically friendly than cotton with comfort properties that exceed cotton
- Promote the "wrinkled look" of linen in North America so wearing wrinkled pure linen becomes as accepted as it is in Europe
- Promote pure linen sourced from lower cost non West European sources
- Get weavers to put non-wrinkle finishes on pure linen to reduce wrinkling in the same way that weavers now use a finish on cotton pants to give wrinkle free cotton pants
- Promote pure linen fabrics and garments in tropical countries that have not been traditional markets for linen but now are experiencing rapidly rising incomes (e.g., countries in the Middle East, India, Indonesia)
- Produce long line linen fiber in Canada where land suitable for growing flax is cheap relative to Western Europe and ship the fiber to countries that have low labor costs and the facilities to spin long line (e.g., China, Korea)

## Constraints

- Customers perceive pure linen to be expensive and very prone to wrinkling
- Chinese, Russian and East European pure linen garments are often not very stylish
- There is no truly international linen based organization that promotes pure linen, regardless of its origin
- The French, Belgians and Irish do some promotion but they only promote the high priced products from their domestic mills
- R&D needs to be done to reduce cost of spinning, weaving and knitting but who will pay for this R&D

- In the last century the wearing of pure linen has been very much influenced by fashion with high demand and prices every five years and stagnant demand and prices in the meantime. This cyclical demand for pure linen makes it difficult for new firms to cash flow their operations for three or four years should they start production just after prices and demand have fallen.
- The spinning of long line linen fibers is labor intensive. On the average, 40 – 50% of the cost of a bleached, printed and finished pure linen fabric is labor and hence even long standing French and Belgian linen firms are moving production facilities to lower wage countries. The relatively high cost of labor in Canada and the USA coupled with the relatively labor intensive nature of pure linen spinning and weaving compared to "the cotton system" would constrain the spinning and weaving of pure linen on a large scale in Canada or the USA (this would not, however, apply to Mexico, the other NAFTA member country), however, even in Canada and the USA there would be room for several small niche linen spinners and weavers.

## Linen Blend Textiles

### Market

- Flax fibers can be blended when weaving as a yarn with other types of yarn or blended during spinning with other fibers
- Traditionally short fibers called tow were blended with other yarns or fibers to give coarser yarns or textured yarns for items like men's sport jackets, upholstery fabrics, homespun looking cotton
- Very good quality short fibers are now also "cottonized" and made to have the length and width of cotton fibers so they can be spun using cotton equipment
- Linen blend textiles can give almost the same level of comfort and/or appearance of pure linen at less cost
- The market for linen blend textiles is growing much faster than market for pure linen because price is more competitive with cotton and blending flax with almost any other fiber will reduce its propensity to wrinkle

### Type of Raw Fibers Used

- Hackled tow, some types of scutched tow

### Technology

- The blending of short linen fibers with other fibers has been done for hundreds of years
- Spinning and weaving productivity is usually reduced when flax fibers are introduced in a blend so financial incentives (e.g., the potential for higher prices or no quotas) must exist for flax fibers to be put in blends
- The more similar the cottonized flax in dimensions to cotton the easier it is to spend on the cotton system machinery

### Capital

- Spinners need almost no additional investments to use small percentages of flax fibers in a blend

### Competition With

- Other fabrics that use niche natural fibers (e.g., ramie, silk, hemp) in a blend to gain a marketing edge
- Cotton and polyester blend fabrics that are made to look like linen blend fabrics but are cheaper and/or easier to care for

- Possible winter flax growing and processing industries in Southern American states (e.g., South Carolina, Georgia, Texas)

## Opportunities

- Promote linen blend textiles for their added comfort, lower price (compared to pure linen), ecological friendliness (compared to cotton and synthetics)
- Cotton quotas to Canada and the USA make it attractive for countries like China to produce and export to Canada and the USA garments containing more than 50% linen (e.g., 55/45 linen/cotton shirts) since fabrics and garments containing more than 50% linen are not considered cotton blend items and hence are not constrained by cotton quotas

## Constraints

- Many cotton system spinners and weavers do not know how to effectively and/or efficiently blend flax tow or cottonized flax into blended yarns or blended fabrics
- Most consumers in North America are not aware of the advantages of linen blend clothing over cotton and hence are not willing to pay more for the extra trouble spinners and weavers must go through to incorporate flax fiber into blends
- World cotton prices fluctuate and several high price years may be followed by several low price years. When the cotton market is depressed, it will be increasingly difficult for cottonized flax to compete with cotton

# Plastic Composites not Used in Building Materials

## Market

- Substitutes for fiberglass where cost, weight, flexibility, degradability and/or "sharp edges" are factors
- End use markets would include automotive and transport sector components, shipping and storage containers, industrial machine parts and other applications
- The present North American market for plastic fillers and reinforcing fibers is estimated to be about 5.5 B lbs (i.e., 2.5 million tonnes) and is growing; the world market would be three to five times larger

## Type of Raw Fibers Used

- Scutched tow and breaker tow (including roughly cleaned oilseed flax fibers), hemp, jute, sisal, coir and kenaf for low and medium end fiber reinforcing applications;
- Wood flour and chalk are the most commonly fillers; several companies are now using chopped wheat straw as a filler
- conventional and chopped long line, hackled tow and cottonized flax for high end reinforcing applications

## Technology

- Can buy tow cleaning systems "off the shelf" but these tend to be high priced and have low capacity; for long run viability need to have lower cost, higher volume breaking and cleaning systems
- Fiber may need to be acelytated if end product has long exposure times to moisture (See Appendix for description of acelylation)

## Capital

- $1-3 Million for cleaning
- $5-50 Million for commercial scale plastic making systems depending on end products; pilot plants could cost considerably less

## Competition With

- Fiberglass
- Other bast fibers
- Wood flour and chopped wheat straw (when used as a filler)

## Opportunities

- Some Saskatchewan based plastic manufacturers use glass fibers as a reinforcing fiber and have expressed interest in trying clean flax fibers

- Raw compressed fibers have a high enough value that they can be shipped throughout North America
- Fiberglass is less environmentally friendly and more uncomfortable to work with than bast fibers in plastic composite factories

## Constraints

- Size of competition (i.e. fiberglass manufacturers are few in number, have large research and development departments)
- Environmental issues – (air quality, water quality, noise, worker safety, dust) may become more of an issue in the future with the manufacture of plastic composites
- Will need to develop some higher end uses or new compression technology to make it financially attractive to ship to some long distance markets

# Plastic Composites used in Building Materials

## Market

- Substitute for structural materials (e.g., 2X4's, 2X8's)
- Other end use products include decking, decorative trim, fencing, shingles, siding and other building materials
- A niche market that is growing quickly as the price of timber products rise
- The market is presently served mostly by using fiberglass or waste from wood mills to make plastic composite building materials

## Type of Raw Fibers Used

- Scutched tow, breaker tow for most applications; conventional and chopped long line, hackled tow and cottonized flax for high end applications

## Technology

- Technology is now in use that uses fiberglass and wood waste; it appears this technology can be relatively easily modified to use flax or hemp fibers especially if these fibers are sold in consistent lots
- New technologies are being developed because of the potential markets that are emerging, especially in areas where wood products are already high priced

## Capital

- $5-50 Million or more depending on the scale of the plant and its ability to access raw materials and inputs from adjoining facilities; pilot plants can probably be built for considerably less

## Competition With

- Existing wood suppliers (may be most difficult to compete in Western Canada or California because wood is still relatively cheap and transport costs for wood are lower from the West Coast to California than from Saskatchewan to California)
- Other long natural fibers (e.g., hemp, jute, sisal, coir) that can be used in plastic composites

## Opportunities

- Building materials made from wood are subject to weathering (e.g., fences, decks, shingles, siding); those made from plastic composites would weather more slowly and would not require as much upkeep (e.g., painting)
- Compared to using glass fibers as a reinforcing fiber, flax fibers are lighter in weight, require less plastic resin to produce the same strength, are easier to deep mold, are easier to recycle and process and cost less

## Constraints

- High transport costs relative to competing areas
- Lack of distribution channels
- Lack of knowledgeable people and industry experience
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- This market needs money for market development

# Insulation

## Market

- Substitute for fiberglass insulation
- Presently a niche market in Europe in situations where a natural degradable insulation product can be sold at a premium over glass fiber insulation
- Initial markets in Europe are largely institutional buildings whose designers want them to be environmentally friendly
- The demand for more environmentally friendly building materials is spreading to North America
- In Europe prices at the retail level are presently roughly double that of fiberglass based insulation
- Prices are expected to drop considerably when flax and hemp insulation plants scale up their operations. If this happens, the demand is expected to grow very quickly since many users would sooner use natural fiber based insulation if it is cost competitive with glass fiber insulation

## Type of Raw Fibers Used

- Scutched tow, re-scutched tow, some types of breaker tow

## Technology

- Technology has already been developed in Europe and at least four firms in Germany are making products
- Flax based insulation can be made rodent, insect and fire resistant with the addition of small amounts of chemical additives
- The finer the fibers, the greater the insulating value for a given volume of insulation batt

## Capital

- $2-10 Million or more depending on the scale of the plant and its ability to access raw materials and inputs from adjoining facilities

## Competition With

- Fiberglass and rock wool insulation
- Insulation made from jute, sisal, wool and other natural fibers

## Opportunities

- Flax and hemp based insulation can be easily disposed of in an environmentally friendly way
- These products cause less itching during installation than fiberglass batts
- Insulation products do not require the degree of consistency of fiber lengths, fiber strength and fiber fineness that textile applications do

## Constraints

- Lack of knowledgeable people and industry experience
- Insulation manufacturers in North America generally have very large scale factories and may not be interested in considering bast fibers for insulation unless there are several large volume suppliers who have consistent quality raw fibers
- Lack of testing by the building industry in North America to allow architects and engineers to specify to their clients, with confidence, flax and hemp based insulation materials for the buildings they are designing and building
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- This market needs money for product and market development
- Fiber mats will rot if moist for a long period of time so not suited for applications where water may enter unless plastic film or other material protects insulation from moisture (although fiberglass does not rot, it does lose much of its insulating value when wet)

# Absorbent Products

## Market

- Over 60% of market volume taken up by personal disposable hygiene products; the growth in volume of these products is growing slowly in the developed world except for adult incontinence products but is growing rapidly overseas
- Market is dominated by several large companies in North America but there is competition to come up with even small improvements that can be promoted to gain market share
- There is a wide variety of niche absorbency products from make-up wipes to mats for oil spills; flax fibers could be incorporated into some of these products to enhance performance and/or to lower the cost of production
- Increased compression during shipping of personal hygiene products is leading to need for a stiffer cellulosic fiber like flax in the inner core of the product because after high compression, commonly used wood fibers do not always spring back to their original shape and hence to not re-create the void spaces the products were originally designed to have
- End users look for high volume fibers where prices are quite stable; to date this has restricted them to wood, synthetic and cotton fibers

## Type of Raw Fibers Used

- Scutched tow, re-scutched tow; perhaps breaker tow after refining; cottonized flax fiber for high end uses

## Technology

- Raw fiber needs to be really consistent and well graded due to highly automated nature of production of end products
- Flax fibers may behave somewhat differently than other fibers presently being used in the processing and manufacturing machines. Research needs to be done to find out how to best optimize manufacturing process for inclusion of flax fibers and to find out which fiber length and fineness is most suited to the manufacturing process
- Plant owners will make the necessary modifications to use alternative fibers if research results and expected fiber acquisition costs and quality justify such changes

## Capital

- $1-5 Million to make fibers similar to cottonized flax but trials needed to clarify what dimensions fibers should have

## Competition With

- Wood fluff – cheaper
- Synthetic fibers – cheap and stiff but not as absorbent and less environmentally friendly
- Cotton linters (i.e., the short cheap cotton fibers which are removed from the seed coat after ginning or short fibers produced during carding operations)
- Other niche natural fibers (e.g., hemp, kenaf) that could be processed cheaply into a form suitable for use in absorbency products

## Opportunities

- R and D needed to show that flax fibers would have a cost or physical property advantage over fibers presently being used
- R and D needed to improve refining of flax fibers

## Constraints

- Lack of knowledgeable people and industry experience
- Lack of research data to support assumptions that flax fibers will add stiffness, void spaces and/or absorption capacity after high compression packaging
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- This market needs money for product and market development

# Geotextiles

## Market

- Geotextiles are textiles placed on or in the soil generally to reduce erosion and/or improve drainage
- Market segments where biodegradability is important (e.g., road embankments)
- New markets may emerge as an underlining between the clay and aggregate layers in road beds
- Freight limits effective market
- Some local market potential at mine sites, construction sites, along road and railway beds
- Biggest markets are in mountainous and/or high rainfall areas and areas where a lot of construction is taking place (e.g., California, Japan, China)

## Type of Raw Fibers Used

- Lower quality scutched tow, breaker tow, flax straw

## Technology

- Does exist but may be problems/modifications needed if dirty fiber or weedy straw

## Capital

- $1-3 Million

## Competition With

- Other bast fibers like jute, sisal and coir
- Synthetic fibers

## Opportunities

- Some local demand
- Some Saskatchewan firms are interested in developing geotextiles from flax and hemp
- Need test performance labs by respected laboratories so engineers will specify it in plans

## Constraints

- Lack of knowledgeable people and industry experience
- Lack of testing by the building industry in North America to allow architects and engineers to specify, with confidence, flax and hemp based geotextiles
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- Many of the large markets for geotextiles are quite distant from Saskatchewan and freight may make it difficult to compete with coir and sisal in such distant markets
- Both domestic and foreign markets needs money for product and market development

# Pulp and Paper

## Market

- Total market for pulp and paper is huge (> 180 million t/yr. worldwide) and there are many large volume niche markets
- Pure flax pulps could be made and then be sold to paper makers who could blend it in with other pulps to make specialty papers or to give wood based papers better properties like added strength or ability to be re-cycled more often or at a higher recycle content

## Type of Raw Fibers Used

- Breaker tow, weed free flax straw

## Technology

- In North America pulp and paper mills are usually very large scale (1,000-3,000 t/day) and operators are generally reluctant to even consider non-wood sources of fiber unless they have assurances of large volume, consistent quality raw material
- Plants in developing countries are generally much smaller and these may offer technologies more appropriate in scale to those needed by possible small scale pulping facilities for flax fibers
- It is cheaper and simpler to make pulp than paper
- Mechanical pulping with minimum or no use of chemicals can reduce capital costs by 30-60% but produce a pulp which is not 100% free of non-cellulosic material and not white
- R&D needed to fine-tune a pulping system for pure flax or pure hemp

## Capital

- Conventional large mill $500-1,000 million
- Small scale pulping much less capital intensive and community pulping operations could be possible providing markets can be found for rough pulp
- In the North American pulping industry "small scale" refers to plants that cost $100-200 million; in developing countries or in craft pulping "small scale" refers to $50,000 to $5 million

## Competition With

- Other specialty pulp sources (hemp, kenaf, cotton rags and textile waste)

## Opportunities

- Tree free chemical free pulp
- Flax fibers can be easily and cheaply bleached
- Oilseed flax may be cheaper raw material than other bast fibers since, in Western Canada most flax straw is just being burnt
- "Total" flax straw pulping may be relatively easy to do and would produce a high yield of pulp relative to wood sources of fiber
- When wood-based newsprint is re-cycled, about 20% of virgin wood fibers must be incorporated in the blend to make the resultant paper strong enough for high speed printing; if flax or hemp fiber are used instead of virgin wood fibers the content of re-cycled fiber can be increased from 80% to 90%, thus increasing the amount of re-cycled paper that can be used

## Constraints

- Canada has big vast amounts of wood (hard/soft) for pulp/paper therefore no shortage of wood fibers
- Large scale alternate processes for pulping flax may have to be developed
- Reluctance of pulp/paper manufacturers to consider integration of bast fibers into their systems
- Fiber production and assembly cannot be considered as a residual farming activity, done without consideration of the needs of the end user
- Have to show paper producers that using flax fibers will add direct economic benefits by enhancing characteristics of existing products or developing unique products
- Primary limiting factors will be the management and marketing ability of industry and companies to finance and launch industrial products, versus solving technical and research issues
- Transport costs are significant because the value per tonne of fiber for paper making is relatively low compared to higher end fiber uses
- Flax straw is only produced once a year and only collected in the spring and autumn and is relatively expensive to transport and store because of its low bulk density. It is flammable and quality characteristics can vary significantly from field to field. This is in contrast to trees which can be harvested and collected throughout the year and are relatively cheap to transport and store because of their relatively high bulk density. Trees are also not as flammable as flax straw and tend to have more consistent quality characteristics because they are produced over many years and can be easily blended once they are chipped

# Fuel

## Market

- No markets established but flax straw and flax shives have high calorific content per kilo and hence could be an attractive fuel/heat source for buildings if straw or shives already collected for other reasons
- In 1998 a student in Agricultural and Bioresource Engineering estimated that the heat from a 40 pound bale of flax straw would be worth roughly $1.00 if natural gas was available, $2.00 if only propane were available and $4.00 if the only other source of heat was heating oil

## Type of Raw Fibers Used

- Flax straw or flax shives

## Technology

- Various feed and furnace systems exist
- May be better to make briquettes/pellets first

## Capital

- $20,000-200,000

## Competition With

- Natural gas
- Propane
- Fuel oil
- Scrap wood
- Coal

## Opportunities

- Local use when straw/shives already collected
- Could be used to dry straw in a flax fiber processing plant; heat water; dry hay
- Greenhouses, barns, etc. in flax areas

## Constraints

- Transport and storage costs relative to value

# Animal Bedding and Feed

## Market

- No formal markets established but flax straw and flax shives have been used by some farmers as bedding for cattle kept outside
- Farmers who use flax straw for bedding report that their cattle stay drier than on wheat straw and that they cattle like to chew on the flax straw
- Chopped flax straw and/or shives may be useful in rations that need a low energy, high fiber ingredient (e.g., as substitute for wheat bran in dry sow rations)

## Type of Raw Fibers Used

- Flax straw or flax shives

## Technology

- Most models of existing hay choppers and feed grinders could be used with little or no modification

## Capital

- $0 - 20,000

## Competition With

- Cereal straw
- Wood shavings
- Wheat bran
- Poor quality hay

## Opportunities

- Local use by farmers who have close access to flax straw and/or shives
- Carry out experiments and/or demonstrations to show when flax straw and/or shives would be more desirable to use that competing products

## Constraints

- Transport and storage costs are high relative to value
- Unless it is chopped flax straw may not be suitable for indoor bedding because of its tendency to wrap around the shafts of manure handling equipment
- Little or not information is available presently to show how the nutritional composition of flax shives or ground flax straw compares other high fiber feed ingredients

# Raw Fiber Market Categories

## Long Line

### Market

Note: See Appendix for definition of long line

- Used to make traditional pure woven linen
- Technology now exists to use it to spin linen yarn that can be used in knitting
- Long line makes the strongest and thinnest diameter (i.e., finest) linen yarn and hence the thinnest and finest linen fabrics
- Market prices range from US$1,500 - 5,000/tonne depending on the quality and the year
- Spinners using this type of fiber located in China, Russia, Italy, Belgium, France, North and South Korea, Tunisia, Brazil, Ireland, Eastern Europe, Austria
- No market now in NAFTA; China is biggest importer

### Important Quality Characteristics

- STRAW: degree of retting , alignment, fiber content, consistency, absence of seed holders, stem length, stem diameter, presence of weeds, moisture content
- FIBER: consistency, strength, fineness, length, color, stiffness, odor, feel

### Technology

- Normally produced from fiber flax varieties but it is possible to produce from taller oilseed flax varieties although the fiber content will not be as high
- Need traditional processing line and pullers, turners and modified balers to keep straw aligned throughout process
- Long line processing systems can be bought "off the shelf" (i.e., no R&D needed) but relatively high cost for a processing unit and necessary field equipment and an experienced operator is needed to get the best performance out of the machinery and raw materials
- Farmers producing for this market must be willing and able to manage this crop much more intensively than oilseed flax
- Flax straw production and retting system must allow fibers to be cleaned totally from shives but the fiber must retain their strength and fineness

### Capital

- $5-15 Million for full scale long line plant and associated field equipment (e.g., pullers, turners) for 5,000 – 10,000 acres
- Less costly if used machinery can be purchased

## Competition With

- Existing long line producers in France, Belgium, Russia, China, etc.
- Other niche natural fibers like ramie, silk and hemp

## Opportunities

- Sell fiber to spinners in low cost countries that have long line spinning facilities
- Sell fiber to spinners in EU that are in countries that do not grow flax (e.g., Italy, Ireland)
- Start a small integrated hackling, spinning and weaving mill to sell into the niche market for products made entirely in Canada or USA from an all natural product
- Start a joint venture with an existing foreign spinner and/or with Fibrex in Quebec who are already producing long line flax fiber from fiber flax grown in Quebec

## Constraints

- High transport costs relative to competing areas
- Lack of knowledgeable people and industry experience
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- No North American suppliers of long line handling equipment so may take time to get parts and service if machines breakdown
- R&D still needed to be done to narrow down the agronomic practices that will give the best long line under Saskatchewan agro-climatic conditions

## Major Beneficiaries if this Type of Fiber is Produced

- Farmers, contract balers, processors, shipping firms, brokers, end users
- Rural job creation and farm net income potential per 1,000 acres the highest of all flax fiber types

# Cottonized Flax for Blending in Textiles

## Market

- Existing cottonized flax market 20,000 - 60,000 tonnes per year
- Potential cottonized flax market in next five years depends very much on cost of raw fiber and cottonizing process
- Growth in blending market in the next five years depends on the price (i.e., at present price of US$1,500 – 3,500/tonne quantity consumed may be similar to present situation but at price of US$950 –1,500/tonne and improved fiber consistency quantity consumed may be 100,000 – 500,000 tonnes per year)

## Type of Raw Fibers Used

- Hackled tow, some types of scutched tow

## Important Quality Characteristics

- STRAW: degree of retting , fiber content, consistency, absence of seed holders, stem diameter, presence of weeds, moisture content
- FIBER: consistency, strength, fineness, color, stiffness, odor, feel

## Technology

- Existing technology for cottonizing uses mechanical systems to separate individual fibers – this leads to high cottonization costs and/or the need to use high quality tow
- With some R&D expenditure there is a good potential to reduce raw material costs and reduce the cost of cottonizing by switching from mechanical cottonizing to alternative cottonizing systems (e.g., enzymes, steam explosion, ultra sound)

## Capital

- Traditional mechanical cottonizing systems are about $1 million but need to have a source of clean high quality tow; non-mechanical systems may be $1 – 3 million but no large scale non-mechanical systems have been built yet

## Competition With

- Existing cottonized flax producers in France, Belgium, Russia, China, etc.
- Cottonized fiber from other niche fiber like ramie and hemp
- Cotton and viscose fibers that are specially treated to give them the appearance of flax fibers

## Opportunities

- Become a low cost cottonized flax supplier

## Constraints

- High transport costs to European destinations
- Lack of knowledgeable people and industry experience
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- R&D still needed to make large scale non-mechanical cottonizing a reality
- Most consumers do not know that a garment or bed sheet containing cottonized is more comfortable than one containing pure cotton and hence are not willing to pay a premium for products containing cottonized flax. Consumer education and clear identification of products containing cottonized flax are both needed before a premium priced mass market can be developed for cottonized flax

## Major Beneficiaries if this Type of Fiber is Produced

- Farmers, contract balers, processors, shipping firms, brokers, end users
- Rural job creation and farm net income potential per 1,000 acres almost as high as long line production because the existing mechanical cottonization systems requires that the raw fiber has properties similar to hackled tow or high end scutched tow. This, in turn, requires more management and labor intensive production and processing techniques. A move to non-mechanical cottonization systems may reduce labor requirements relative to a mechanical system but even highly mechanized processing of high value fibers like cotton creates many more jobs per 1,000 acres than the production and processing of major crops for seed

# Hackled Tow

## Market

Note: see Appendix for definition of hackled tow

- Used to make coarser pure linen yarns
- Used to mechanically produce cottonized flax because of its fine fiber division (i.e., low wastage factor during mechanical cottonization)
- Roughly 40 – 60% of the value of long line
- Marker prices range from US$700 – 2,000/tonne depending on the quality and the year
- Spinners using this type of fiber located in China, Russia, Italy, Belgium, France, North and South Korea, Tunisia, Brazil, Ireland, Eastern Europe, Austria
- No market now in NAFTA; China is biggest importer

## Important Quality Characteristics

- STRAW: degree of retting, fiber content, consistency, absence of seed holders, stem length, stem diameter, presence of weeds, moisture content
- FIBER: consistency, strength, fineness, length, color, stiffness, odor, feel

## Technology

- Need traditional processing line and pullers, turners and modified balers to keep straw aligned throughout process
- A by product produced when long line is hackled (i.e., combed)
- Could be produced in a simpler manner with a "total fiber" system that does not keep straw or fibers aligned during breaking and cleaning
- Hackling systems can be bought "off the shelf" (i.e., no R&D needed) but relatively high cost for a processing unit and experienced operators are needed to effectively operate the system
- Farmers producing for this market must be willing and able to manage this crop much more intensively than oilseed flax
- Flax straw production and retting system must allow fibers to be cleaned totally from shives but the fiber must retain their strength and fineness

## Capital

- $1-2 Million for hackling plant with one or two lines (assuming long line can be purchased or obtained from an existing facility)
- Less costly if used machinery can be purchased

## Competition With

- Existing hackled tow producers in France, Belgium, Russia, China, etc.
- Other niche natural fibers like ramie, silk and hemp

## Opportunities

- Sell hackled sliver to spinners or cottonizers in low cost countries that can handle hackled tow
- Sell hackled sliver to spinners or cottonizers in EU countries that do not grow flax (e.g., Italy, Ireland)
- Start a small hackling, spinning and weaving mill to sell into the niche market for products made entirely in Canada or USA from an all natural product

## Constraints

- High transport costs to European destinations
- Lack of knowledgeable people and industry experience
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- No North American suppliers of hackling equipment so may take time to get parts and service if machines breakdown
- R&D still needed to be done to narrow down the agronomic practices that will give the best hackled tow under Saskatchewan agro-climatic conditions

## Major Beneficiaries if this Type of Fiber is Produced

- Farmers, contract balers, processors, shipping firms, brokers, end users
- Rural job creation and farm net income potential per 1,000 acres almost as high as for long line or cottonized flax production because the production of such high value fibers, even if very mechanized, still requires more labor than the production and/or processing of large volume crops for seed

# Scutched Tow

## Market

Note: See Appendix for definition of scutched tow

- Best qualities are re-scutched and used for blending in textiles or for cottonizing
- Generally used to make mats for plastic composites, insulation bats, filters and geotextiles
- Poorest qualities may be used in the pulping market when prices are low
- Marker prices range from US$300 - 600/tonne depending on the quality and the year
- End users buying this type of fiber located in throughout Europe, some areas of Asia and North America

## Important Quality Characteristics

- STRAW: degree of retting, fiber content, consistency, absence of seed holders, presence of weeds, moisture content
- FIBER: consistency, strength, length, stiffness, odor

## Technology

- Traditionally produced as a by product of the long line scutching process
- Could be produced in a simpler manner with a "total fiber" system that does not keep straw or fibers aligned during breaking and cleaning
- Scutched tow cleaning lines can be bought "off the shelf" (i.e., no R&D needed) but they are relatively high cost with a low throughput per hour and are really only suited for adding on to existing long line processing lines
- There is need to develop several much larger scale systems that can be used to directly produce unaligned straw into tow similar in quality to scutched tow but with much lower per tonne processing charges (i.e., like the Durafiber system but with modifications for retted and over-retted straw)
- Farmers producing for this market may have to make small changes to their traditional oilseed flax cultural practices to optimize the quality and quantity of fiber that can be produced from their oilseed crops
- It is likely that the main source of straw for scutched tow will come from the by product of long line processing or from oilseed flax

## Capital

- $2-5 Million for full scale "total fiber" decorticating plant to handle 40,000 – 60,000 tonnes of straw
- $200,000 – 600,000 if a tow cleaning line is added to an existing long line processing line
- Less costly if used machinery can be purchased

## Competition With

- Existing scutched tow producers in France, Belgium, Russia, China, etc.
- Other low end, lower priced natural fibers like jute, sisal, abaca and lower quality hemp
- Synthetic fibers for geotextiles
- Glass fibers (i.e., fiberglass) in plastic composites

## Opportunities

- Sell fiber to North American manufacturers of plastic composites, geotextiles, insulation and building materials
- Sell fiber to up-market end-users off-shore at destinations where shipping costs do not eat up all the profit

## Constraints

- High transport costs relative to competing areas
- Lack of knowledgeable people and industry experience
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots
- R&D still needed to be done to narrow down the agronomic practices that will give the optimum trade-off between seed yields, fiber yields and fiber quality under Saskatchewan agro-climatic conditions

## Major Beneficiaries if this Type of Fiber is Produced

- Contract balers, processors, shipping firms, brokers, end users
- Rural job creation and farm net income potential per 1,000 acres much less that with higher end flax fiber types

# Breaker Tow

## Market

Note: See Appendix for definition of breaker tow

- Usually used in specialty pulps and papers
- Marker prices range from US$150 - 400/tonne depending on the quality and the year
- The most important industrial scale pulpers that use Canadian oilseed breaker tow are located in New Jersey and North Carolina. A dedicated flax pulping facility operates in Spain. Pulping plants that use flax in at least some of their pulps are not common but can be found in Europe, Asia and Africa

## Important Quality Characteristics

- STRAW: fiber content, absence of seed holders, presence of weeds, moisture content
- FIBER: strength, odor, color in cases where no bleaching treatment is done

## Technology

- Breaker tow is a by product of traditional long line processing
- Several companies have developed their own systems of decorticating under-retted oilseed flax straw; generally these systems are kept as trade secrets and not patented
- During chemical pulping operations, heat and strong chemicals are used to dissolve all but the cellulosic fibers. This means that pulpers can handle significant levels of shives without it detrimentally affecting the quality of the pulp and hence pulpers will buy flax fiber that has a considerable amount of shives

## Capital

- $1-3 Million for full scale decorticating line for oilseed flax straw
- $50,000 – 200,00 for rough cleaning and baling system if part of a long line processing plant
- Less costly if used machinery can be purchased

## Competition With

- Existing breaker tow producers in France, Belgium, Russia, China, etc.
- Other low value cellulosic fibers like wood, kenaf, hemp and abaca

## Opportunities

- Sell breaker tow to pulpers who are now using roughly cleaned flax fiber;
- Set up a small pulping operation that will use locally sourced breaker tow to produce flax based pulps that can then be sold to specialty paper makers in other parts of the world (i.e., minimize the negative impact of high shipping costs from Saskatchewan by shipping higher value more dense pulp rather than lower value less dense dirty fibers)

## Constraints

- High transport costs relative to competing areas
- Existing breaker tow producers on the Prairies may try to use their market influence to limit access to existing pulpers of breaker tow
- Lack of industry accepted measurement standards for quality attributes to enable proper price signals to buyers and sellers of straw and fiber and to allow suitable blending of raw materials and fiber lots

## Major Beneficiaries if this Type of Fiber is Produced

- Contract balers, processors, shipping firms, brokers, end users
- Rural job creation and farm net income potential per 1,000 acres even less than with scutched tow

# Shives

## Market

- In Europe traditionally used for fuel and particle board
- Have often been used as bedding in dairy barns
- Is now being sold into the specialized animal bedding market
- Can be used in place of wood flour as a filler in plastic composites. Research has shown the "aspect ratio" is superior to most wood flours and hence that it should be able to eventually achieve a market price 30 – 60% higher than wood flour
- Marker prices range from US$30 to 300/tonne depending on the quality and end-use
- End-users normally located quite close to source of shives because this is a low density product that is generally not profitable to ship long distances

## Important Quality Characteristics

- SHIVES: consistency, absence of dust, particle size

## Technology

- Extraction of dust and the sizing or screening of particles can be done to increase the desirability of the product in the eyes of end-users
- Technology exists to grind and screen shives to the size desired by end-users

## Capital

- $5,000 – 200,000 for dust cleaning and screening equipment
- relatively low capital cost due to the fact that shives are always a by product of flax straw processing
- Less costly if used machinery can be purchased

## Competition With

- Existing producers of wood chips and flour and straw and hemp bedding materials

## Opportunities

- Sell shives as an exotic animal bedding material
- Sell shives to local dairies and feedlots
- Grind and sell as a substitute for wood flour as a filler in plastic composites
- Use for plant mulches and potting mixes
- Use shives inside the processing plant as a source of heat

- Find chemicals to add to shives to enhance their performance as a plastic filler

## Constraints

- High transport costs and a low density material make it unprofitable to ship to many locations
- Local bedding material market for large animals is easily served by existing cheap supplies of wheat straw from local farmers or by free wood chips from tree peeling operations in Northern Saskatchewan (although these chips are free at the mill they must be transported a hundred or more miles before they can be used.)
- Local horse and pet bedding market is very small

## Major Beneficiaries if Shives Produced

- Processors, shipping firms, brokers, end users
- Rural job creation and farm net income potential per 1,000 acres would be highly related to the type of fiber that is produced when the shives are produced

# Whole Flax Straw

## Market

- Traditionally used an a type of geotextile to reduce water erosion
- Could be used as a raw material for specialty pulps or oriented strand board

## Important Quality Characteristics

- STRAW: fiber content, lignin content, presence of weeds, moisture content

## Technology

- Pulpers need to have research trials to show them how to use whole flax straw and what the advantages and disadvantages will be
- Straw would have to be chopped before entering traditional wood pulp processing lines
- No new technology would be needed at the farm level since farmers could just bale up their residual oilseed flax straw

## Capital

- $10,000 – 200,000 for the addition of bale unrolling and chopping equipment in front of existing wood pulping lines
- Less costly if used machinery can be purchased

## Competition With

- Wood pulp
- Cereal straw for bedding and OSB board manufacture

## Opportunities

- Sell flax bales to wood pulping or oriented strand board operations in northern Saskatchewan, Alberta and Manitoba
- Set up a small pulping operation that would only use whole flax straw as a pulping raw material
- Promote flax straw as a superior bedding material for cattle kept outside (i.e., it keeps cattle drier than cereal straw)

## Constraints

- High transport costs and a very low density, low value raw material could make it unprofitable to ship most flax straw up to northern pulping operations
- Wood pulping operations are very large scale and have no experience pulping flax straw
- relative to competing areas

## Major Beneficiaries if this Type of Fiber is Produced

- Contract balers, contract haulers of straw, pulpers, end users
- Rural job creation and farm net income potential per 1,000 acres the smallest of all flax fiber/straw options but would reduce the amount of straw that is burnt

# Appendix C

# Flax Fiber Related Trip Report

Of Linda Braun and Alvin Ulrich

To

Florida, Georgia and South Carolina

October 1999

AND

# ASTM Meeting

Charlotte, North Carolina

March 2000

*The author gratefully acknowledges the financial support from The Agricultural Development Fund of Saskatchewan (ADF) and the Saskatchewan Flax Development Commission that made this trip possible.*

**Trip Duration:** October 2 to 9, 1999

**Locations:**
Fort Lauderdale, Florida
Athens, Georgia
Clemson, South Carolina

**Participants:**
Alvin Ulrich
Linda Braun

**Trip Objectives**
Gain an understanding of the cotton/textiles industry
Gain an understanding of the fiber industry and meet key industry players
Introduce Canadian players to the industry
Become a leading player in ASTM operations to develop standards for flax fiber (applicable to Canadian flax industry)
Initiate market research regarding natural fibers
Gather and compile information for Flax and Hemp fiber R & D Strategic Plan (ADF funded) Project

**Events/Places:**
Flight from Saskatoon to Ft. Lauderdale – Oct. 2nd

Meet with some participants and free time (Sunday) – Oct. 3rd

ASTM (American Society For Testing and Materials) Meeting, Ft. Lauderdale, Florida

| | |
|---|---|
| D13.17 | Subcommittee Flax (Linen Content) Products – Oct. 4th |
| D13.13 | Subcommittee Wool and Wool Felts – Oct. 5th |
| D13.11 | Subcommittee Cotton and Fibers – Oct. 5th |
| D13.16 | Subcommittee Ropes and Cordage - Oct. 5th |
| D13.18 | Subcommittee Glass Fibers – Oct. 5th |
| D13 | Main Committee Session 1 – Oct. 5th |

USDA-ARS-Russell Research Center, Athens, Georgia – Oct. 6th
University of Georgia, College of Textiles, Athens, Georgia – Oct. 6th

West Point Stevens Clemson Facility, Clemson, SC – Oct. 7th
USDA-ARS Cotton Quality Research Station, Clemson, SC – Oct. 7th

School of Textiles, Fiber and Polymer Science, University of Clemson, Clemson, SC - Oct. 8th.
Avondale Mills, Walhalla, SC – Oct. 8th

Flight from Ft. Lauderdale to Saskatoon October 9th

## Events/Places Summary:

### ASTM

- ASTM is a not for profit organization providing a forum for the development and publication of voluntary consensus standards for materials, products, systems and services.
- Represents producers, processors, users, ultimate consumers, government, and academia from one hundred countries; approximately 34,000 volunteer members. There are 131 technical committees.
- D13.17 Subcommittee Flax (Linen Content) Products was formed in January 1999 at the request of the Center for American Flax Fibre.
- Subcommittee scope "To implement the scope of D13 with particular reference to flax in stem, fibre, bundles or as ultimate fibers including line flax, tow, refined (cottonized) flax, sliver, noils, and shives for application in textiles, pulp paper and wet laid non-woven, mechanical non-woven, composites and panel boards, plastic fillers at processing stages including agricultural production, processing, fabricating, converting and marketing."
- January 1998 meeting established five task groups: non-fibre (trash), fiber length, fiber strength, color, and fineness. Committee (task groups) met March 14, 1999 in Seattle. March meeting combined length, strength and fineness into one task group.

*October 4, 1999*

- Meeting attendees: Danny Akin (USDA); Roy Dodd (Clemson); Patty Annis (University of Georgia); Lewis Orchard (Chair); Dave Hammelsbach (USDA), Herb Morison (USDA); Brenda Patterson (Cotton Inc); Carl Domas (Caroline Flax); Jean-Christope Ponsin (Sanelink Corporation); Harry Gilberton (British Fibre); Bob Niester (Chesterfield Yarn Mills); Josef Dospiva (Dospiva); Alvin Ulrich and Linda Braun.
- Task groups presented work undertaken since March meeting – color, trash, length, strength, fineness. Decisions to move ahead with drafting a paper related to color.
- Bob Stobart, Chair of the Wool and Woolfelt Committees joined the group to share information related to wool testing procedures which may be of interest to the flax subcommittee.
- Next meeting is March 26 to 29, 2000 Charlotte, North Carolina.

*October 5, 1999*

D13.13 Wool and Wool Felt

- Wool and Woolfelt meeting postponed (Alvin later talked and had lunch with Bob Stobart, Committee Chair). Dr. Stobart said that the wool processing industry is dying in the USA and there are no important unresolved standards problems in the American wool industry at this time. He stressed that it is important for a least some wool sub-committee work and resolutions to continue so that ASTM standards for wool remain in place.

## D13.11 Cotton and Cotton Fibers

- Subcommittee Chair was unavailable due to family illness. Subcommittee met to discuss standards pending or under review regarding cotton standards. It was interesting to see that there are still disagreements and issues to resolve even though the cotton committee has been meeting for many years. New technologies and new uses continue to create demand for new or modified standards and testing methods.

## D13.16 Ropes and Cordage

- Discussion centered around removal of natural fibers from standards.

## D13.18 Glass Fibers

- This committee was similar to the wool committee in that only the committee chair, Steve Parks, and Alvin Ulrich attended. However, unlike the American wool processing industry, the American glass fiber industry is growing. The Chairman felt there were no other attendees because there were no pressing standards problems at this time. In addition, Dow-Corning and PPG dominate the glass fiber industry in the USA and these two companies often establish their own private standards with certain end-users. The Chairman emphasized the importance of always having some sub-committee work go on so that ASTM standards for that sub-committee remain in place.

## D13 Main Session

- All subcommittee groups presented reports and actions taken, at the Main Textiles Session. The Main session included people from all the Textile Sub-committees that were in attendance.
- After the Main Session met briefly with the Chair of ASTM to discuss operations, membership, standards (development, revision, participation, etc.).
- All sub-committee resolutions must eventually be passed by the main committee (i.e., Textiles) and even though resolutions are passed at the sub-committee level, they are not always passed by the main committee or by the even higher level ASTM general committee. Rejection of sub-committee resolutions may be for such things as insufficient documentation of testing procedures, inability to easily reproduce results, too much bias and systematic error in the results and/or lack of broad industry representation within a sub-committee.
- In any sub-committee, a company or organization can be only represented by one person (i.e., that company or organization has only one vote) regardless of how many people the company may send to an ASTM sub-committee meeting.

In the evening of October 5th, Ms. Braun & Mr. Ulrich flew from Ft. Lauderdale to Atlanta, rented a car and stayed overnight near the Atlanta airport before travelling about 2 hours to Athens, Georgia.

*October 6th, 1999*

## USDA-ARS-Russell Research Center – Athens

- Met with Dr. Danny Akin, Doug Archibald and Herb Morrison.
- The Research Center has 400 employees (2/3 ag. services, 1/3 food inspection).
- Danny is project leader on the flax project and has been working on enzyme retting of flax for several years. Within the last year, he has used approximately eight different enzyme combinations to treat unretted and partially retted flax straw.
- The enzyme retted straw was then cleaned and sent for spinning on the ring spinning system. Samples included several fiber varieties and one oilseed variety.
- The yarns thus produced look promising. They are better than yarns produced from some field-retted straw but not as good as the best yarns made from the best field retted straw.
- Doug showed us around labs and gave several electronic microscopes scans of flax fiber.
- Doug has been analyzing samples using (NIR) to develop a standard process that would be acceptable, require a much larger database to prove the process.
- Discussion ensued regarding partnership potential and testing of Canadian flax straw samples to enlarge the Russell Research Center's straw database.
- Nolan Etters, University of Georgia, College of Consumer Studies, toured us around the college and explained their programs currently underway related to textiles.

In the evening Ms. Braun and Mr. Ulrich drove approximately one and a half hours from Athens, Georgia to Clemson, South Carolina where they spent the night.

*October 7th, 1999*

- We were met in the hotel at 8:00 A.M. by Dr. Roy Dodd and his assistant, John Foulk. They outlined arrangements they had made for us for the next two days. Due to Dr. Dodd's busy schedule, he was only able to tour us around the Clemson University fiber research facilities and Avondale Mills on October 8th. He was also able to invite us to his home on the evening of October 7th for a barbecue.

## West Point Stevens Clemson Facility Tour

- John Folk drove Ms. Braun and Mr. Ulrich about 15 minutes out of Clemson to this plant. It is said to be the largest totally integrated plant under one roof in the world.
- Unlike most textile mills, this facility starts with raw fibers at one end of the plant and ends up with retail ready packages of bedsheets and pillow cases at the other end. Fiber bales are open and blended; fibers are spun into yarn, the yarn is woven into fabric, the fabric is bleached, dyed, printed and finished; it is then cut, sewn, trimmed, packaged, labeled, stored and finally loaded on trucks for further distribution and sale.
- Harry Hancock, Q.C. Manager toured us through the plant. It is one of the largest bed sheet/pillow case plants in North America and has over 2,300 employees. It

processes approximately 300,000-500,000 pounds of polyester and 300,000 to 500,000 pounds of cotton weekly depending on the type of bed linen they are making (i.e., 100% cotton and cotton/polyester blends). The plant is very automated and, in addition to producing their own brand of West Point Stevens bedsheets, they produce a wide range of bed linens for other brands (e.g., Riggs Stevens, Martha Stewart Living, Ralph Lauren, etc.).

- Mr. Hancock pointed out that for their plant to stay competitive, efficiency is the name of the game and that no fibers other than cotton and polyester would be used unless the new fiber (e.g., flax) could be spun, wove and dyed at efficiency levels similar to those of cotton and polyester.

## *USDA-ARS Cotton Quality Research Station*

- This USDA facility is located on the outskirts of Clemson and several miles from the University of Clemson campus.
- This station is one of several in the USA that are devoted to testing and monitoring the quality of cotton used in the USA
- It has a series of temperature and humidity controlled rooms that serve as workshops for various fiber related testing facilities. These include a room containing full scale, but small sections of fiber opening and cleaning equipment, sliver and roving formation machines and ring and open-end spinning frames.
- Previous lab directors wanted to work only with cotton but the new director wants to work with cotton blends and has also agreed to the installation of equipment that would enable them to spin flax fibers more effectively.
- The lab has worked for many years on determining how fiber properties like fineness, length distribution, strength, etc. impact on the quality and quantity of yarn that can be produced from a particular batch of fiber
- They have a wide and varied collection of devices that have been used to determine particular fiber properties.
- In the past, this lab devoted a great deal of time and effort helping to develop the High Velocity Instrumentation (HVI) computerized measurement system that is now the industry standard to measure fiber quality characteristics throughout the American cotton industry.

## *University of Clemson*

- John Folk explained that the University's flax program has been carried out in conjunction Dr. Aki's USDA flax enzyme project at Athens. Utilizing the enzyme retted and semi-cottonized flax from USDA, the cotton research lab spun flax samples and compared it to cotton. So far all yarns were below grade. Shives and color have been problems, but even with these problems, the flax fibers was spun using cotton equipment. From their perspective, there is a lot of potential because the flax yarn spun on cotton equipment shows promising attributes.
- Dr. Dodd met with us to talk about the agronomics of flax production in South Carolina. The state hopes to grow 40,000 acres of fiber flax, as a winter crop in

rotation with cotton and this would be part of the state's agricultural diversification effort.

- USDA and the University of Clemson are in partnership to set up a pilot plant. A firm is designing equipment in the Czech Republic.
- The University of Clemson interested in partnering (sharing of information) to establish flax fiber as an industry.
- Following this introduction, we were given a tour of the School of Textiles, Fiber and Polymer Science in the College of Engineering and Science at Clemson University. The School has a wide range of equipment, from the very old to the very new and the facilities are used for both teaching and research.

## *Avondale Mills, Walhalla*

- This mill is one of several spinning mills in a larger textiles–related company. It carries out custom spinning of cotton, synthetic and cotton/synthetic blends for a variety of customers.
- It employs 80 – 120 people and tries to run two to three shifts every 24 hours and seven days a week if possible.
- The building is over 100 years old but most of the equipment is less than ten years old and consists of quite automated equipment for fiber opening, blending, sliver forming and open-end spinning.
- This mill is producing "commodity yarns" similar to those that can be produced in many countries of the world. It must pay relative high wages (compared to developing countries) and hence needs to be very automated and be able to quickly change to a new order. These factors make it an unlikely user of cottonized flax fibers in the future, unless cottonized flax can be graded and sold like cotton.

In the evening Ms. Braun and Mr. Ulrich drove approximately two hours from Clemson, SC to the south side of Atlanta where they spent the night before catching their flight to Minneapolis and Saskatoon on Oct. 9th.

## Future Directives:

- Investigate ASTM subcommittees for cotton, wool, glass fibers, rope/cordage, non-woven, composites, and plastics, and participate in the subcommittee on flax. Determine committee chairs, work in progress, how fiber fits in; what do we need to do to fit in; and rationale for joining that committee. Are any of our experts already involved?
- What standards exist and what can be adapted for flax.
- Set up a fiber dictionary for use in Saskatchewan – (e.g., define cottonized flax, tow, etc.).
- Set up an industry directory – who's who; what they do and offer.
- Develop rationale/proposal for a Saskatchewan fiber Specialist.
- Develop a communication network of fiber "experts" from Saskatchewan.

- Important to seek out industry (commercialization) players to determine their needs and encourage their participation in the process.
- Seek funding to partner with USDA regarding flax fiber analysis.
- Liaise with fiber companies (i.e. British Fibre, Saneco, DuraFibre, Schweitzer-Mauduit); encourage their participation in ASTM, etc.
- Membership in ASTM - Individual or organizational?
- Investigate:
  - American fiber Manufacturers' Association (AFMA)
  - Association of Non-Woven Fabrics Industry
  - Cordage Institute
  - Industrial Fabrics Association International
  - Association of Non-Woven Fabrics Industry (INDA)

**Event:**

***ASTM Meetings***

March 27 to 29, 2000
Charlotte, North Carolina

### *Sub Committee Linen/Flax Products*

Attendees 9 people representing research, regulation (USDA); Cotton Incorporated, industry and academia. Meeting chaired by D. Akin.
Spain to remain strong; Russia/China still players although Russia had bad crops for the last two years.
Long line fiber flax price is twice the October 1999 prices.
In the U.S. some are putting flax in lay down bales less than 25%, some 50% flax/rayon blend.
In France, it is common for firms often make cottonized flax by first cutting flax sliver into 1.3 to 1.5 inches lengths but they also cut some at 2 inches before cottonizing
In France and Belgium flax slivers are also cut into five or six inch lengths for use in the wool system.
U.S. looking at mowing versus pulling flax plants.
Economics – very rough estimate of cost is approximately $.50 per pound.
Colour problem ranging from light to very dark.
Important to check/compare standards/tests from around the world.
Important to match terminology from around the world.
Important to liaise with people in Europe (i.e. ITF – French Textile Institute).
Don't measure strength in France – long fiber strength is estimated.
Problems – mill conditions (humidity and temperature – flax had to be 70 to 75% humidity).
Trash – Herb reported work on trash project. Seed flax versus fiber flax; non-retted/enzyme retted) – using NIR to develop trash content and fibre. At least a year away from process evaluation methods.
Next meeting is October 22 to 25, 2000 at Orlando, Florida.

Tasks: terminology task group to form a document, sub-committee, sub-ballot regarding colour.

- ISO – Coordinating Committee and Foreign Standards
  Different countries have different laws, symbols, etc.
  Federal trade Commission agrees with international concepts of fiber content, labeling – suggested to develop a practice then move to labeling.
  ISO founded in 1947. Geneva, voluntary, consensus based, 134 members.
  ANSI (American National Standards Institute) – membership is 150; ASTI member of ANSI
  U.S. participates in ISO – develop new markets; trade barrier ease, development of international standards.
  Discussed process/politics to date, U.S. not really happy with process and number of votes, (maintains EU blocks and controls happening).
  Sub-committee meetings I was interested in but did not meet as no members showed.
  Conversed with ASTM staff regarding procedures, organizational structures, etc.
  Came home with ASTM Textile Standard Guides (reviewed guides to get a handle on current standards which may impact on fiber flax standards development).

**Observations/Recommendations:**

- Meet with Bioresource Engineering to determine what standards guises would be valuable for fiber strategic plan.
- Encourage membership of Canadians.
- Investigate other committees (i.e. plastic components).
- Meet with Canadian Council of Standards

# Appendix D

# Flax Fiber Related Trip Report

Of Alvin Ulrich*

To Europe and South Carolina

**March/April 2000**

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* Chris Hale and Terry Boehm of Saskatchewan Flax Development Commission accompanied Mr. Ulrich while he was in Germany, France, Belgium and Holland.

*The author gratefully acknowledges the financial support from The Agricultural Development Fund of Saskatchewan (ADF) and the Saskatchewan Flax Development Commission that made this trip possible.*

# Fiber Related Trip Report of Alvin Ulrich* to Europe and South Carolina

March/April 2000

Friday-Saturday, March 17 –18th

-Mr. Ulrich flew Saskatoon – Toronto – Frankfurt – Moscow and arrived at Moscow airport at 6:00 PM Saturday, March 18th. He was met by Tatiana Rozimina who had arranged for a car to take her and Mr. Ulrich that evening to Torzhok, roughly three hours drive northwest of Moscow on the main highway to St. Petersburg. Mr. Ulrich was taken to a "sanatorium" or health resort about two miles from the small city of Torzhok (70,000 people) and arrangements were made for a room and meals for the duration of Mr. Ulrich's visit to Torzhok because the standard of accommodation was considered much better than anything available in Torzhok city.

Sunday, March 19th

-Mr. Ulrich was met by Tatiana and another employee of the VNIIL (All Russia Flax Institute) with a car and taken to see an outdoor museum of old Russian buildings, the Pushkin Museum of Torzhok, various civic and commercial buildings in Torzhok and Tatiana's apartment for lunch.

Monday-Thursday, March 20th to 23rd

-Every morning the VNIIL would send a vehicle to pick Alvin up at the sanatorium and take him to one of the three buildings belonging to VNIIL in Torzhok. For lunch and supper he was brought back to the sanatorium. Different sections of VNILL brought food and drink from home on four different occasions to have little receptions to honor their foreign guest. This was certainly a warm and touching gesture on behalf of the staff of VNIIL, who, at this time, are receiving no or very low salaries from VNIIL due to the dismal financial state of the Russian economy and government research institutions.

-An introductory meeting was held with the Director, Anatoly Marchenov and several of his colleagues. The VNILL is 60 years old and has spent much of this time breeding improved fiber and oilseed flax varieties and carrying out research in the areas of agronomy, processing and testing fibers. The Breeding Department has Sections for Biotechnology, Genetics, Diseases and Breeding. The Seed Production Department has Sections for Seed Standards and Laboratories for Seed Growing. The Agronomy Department has Sections that deal with, Agronomic Practices, Agro-Chemicals and Protection. The Technology Department has a Section which deals with Development of Technology and one which deals with Standardization of Raw Materials. In VNILL at present there are two scientists with Ph.Ds, 45 scientists without Ph.Ds, 22 candidates of science and 66 support staff for a total of 178 employees. After this introduction, Mr. Ulrich was taken on a short tour by Tatiana Rozhmina of the flax gene bank and the Genetics Section of VNIIL.

-Mr. Ulrich spend most of the week with Dr. Vladimir Mukhin at two smaller VNIIL buildings where straw and fiber are measured, retted, dried, processed in various ways and tested. At the present time it appears that almost no work is being done because of lack of funding and because the flax crop in the Oblast surrounding Torzhok was not harvested for fiber last autumn due to drought and poor weed control. However, Dr. Mukhin's staff were able to find straw and fiber from previous years to demonstrate to Mr. Ulrich how various instruments are used to test properties of flax straw and cleaned fibers.

-Since the 1960s the former Soviet Union has had a set of national standards to test various properties of flax straw and fiber. These standards are much like Canadian Grain Commission standards in that they specify how the raw material is to be conditioned or prepared before testing, what machines will be used for the tests, how the raw material and machine will be treated by the human operator and how the results will be reported and interpreted. The goal of this system is to have objective methods of measuring the quality of flax straw and fiber. After the traits of a sample of straw or fibers are tested (e.g., stem diameter, stem length, fiber color, fiber strength, etc.), the results of the test measurements of different properties are taken and used with a series of numerical tables to generate an index number for stem diameter, stem length, fiber color, fiber strength, etc. These index numbers are, in turn, combined together using another set of numerical tables to give a final index number that is said to represent the approximate relative processing value of straw (for long line fiber production) of a particular sample of straw or the relative spinning value of a particular sample of fiber. The numerical tables that are used are issued as part of the National Standards for Flax Fiber system and represent many years of straw processing and spinning experience. Dr. Mukhin said that China, the Baltic countries, Ukraine and Belyrussia adopted the Russian National Standards for Flax Fiber as their national standards, however, over time, the Chinese have added or modified some of the tests to better reflect changing market demands and/or changes in technology. Mr. Ulrich was given a brief demonstration of many of the tests that were used, however, the actual protocols are written in Russian and no English translations were available. Staff at VNIIL said that anyone actually planning to implement such testing methods should have the protocols translated so that all the procedures and assumptions are clear.

-Although I asked several times, I could not get a cost for the translation of these protocols; I suspect it was a combination of not knowing: exactly which protocols would be useful; how many pages these useful protocols actually were; and how much the foreigners would be willing to pay (however, I was told that the Russian Foreign Affairs Bureau has set standard translation fees for various types of documents). Since the National Standards contain many protocols for tests which may be of no interest to us at this time (e.g., testing pure linen yarn strength, testing the elasticity of a linen blend fabric, etc.) we should really list the tests and protocols that we are interested in and than ask for a quote for the translation of these. In any case, translation from Russian to English will, no doubt, be much cheaper if it is done in Russia than if it is done in Canada.

The following is a brief outline of many of the tests that are routinely carried out.

### STRAW QUALITY

*Straw Length* – Take 10 little "sheaves" (i.e., bundles of 75 – 100 stems) from a one kilo sample and tap the root ends on a table top three times to align the bottom ends; place each sheaf, in turn, in measuring device holder and measure the height. The measuring device is like a 1.5 meter long meter stick positioned on a stand with two half circular holders to hold the straw. There is a flat 290 gm plate shaped like a paint can lid attached to hinged arms that slide up and down the meter stick. The lid and its arms are pushed to the top of the measuring stick and then allowed to slide slowly down until there are enough stem tips supporting the lid so that it does not fall further. The arms of the lid are then adjusted to make sure they are parallel with the lid. The height of the sheaf is then read from the point where the arms intersect the markings on the measuring stick. The average height of the one kilo sample is the simple average of the heights of the ten little sheaves.

*Straw Stem Diameter* – Take ten stems from each sheaf used in the height measurement (see above) and place the ten stems flat. At the approximate middle of the stems measure the combined width of the ten stems and divide by ten to get the average width. If the average width is greater than 1.5 mm, the straw is normally downgraded. There is an optimum relationship between diameters and height of stems and taller stems can be slightly thicker without downgrading the quality. (This is based on experience which shows that thinner stems have a higher percentage of fiber for a given weight of straw, hence a processor has a greater yield of fiber and can extract more financial value if the straw being processed has a high percentage of fine stems). There is a table that shows optimum length/diameter relationships and this will indicate whether or not the straw should be downgraded. For instance, if the length is 75 cm and the diameter is 1.5 mm, 75 is divided by 1.5 to give a "score" of 50. If a new sample was compared to this "base" sample, a score higher than 50 would mean, all other things being equal, the new sample had straw that was better quality than the base sample and a score lower than 50, all other things being equal, would mean the new sample had straw that was of a lower quality than the base sample.

*Straw Fiber Content* – A weighed sample of retted or unretted straw is passed back and forth through a little hand cranked two roller system (ML-3) or through a motorized set of ten rollers (ML-5). The rollers have a standard profile and pressure. Straw is passed back and forth and sometimes shaken between passes until no shives are visible and/or until no more weight loss is taking place. Long retted straw is obviously easier to clean with these two devices than short jumbled unretted straw but it was amazing how almost all the shives could eventually be taken out of almost every type of sample. After the clean fibers are extracted, they are weighed and the percent bast fiber is calculated by dividing the clean bast fiber weight by the original straw weight.

*Straw Strength* – Take three samples of ten stems (roughly three grams). Cut a 27 cm length of straw from near the bottom of each stem in the first sample. Cut a 27 cm length of straw from around the middle of each stem in the second sample. Cut a 27 cm length of straw from near the top of each stem in the third sample. Take one gram of straw from each of the 27 cm length samples. Crush four times using the above mentioned manual or motorized crushing rollers (i.e., the ones used to estimate fiber content) making sure the pressure on the rollers is set at 12 kg/cm2). Put crushed straw sample around pins and clamps in the horizontal dynamometer (DKV-60 or RMP-1) and turn on machine. The dynamometer will gradually stretch the crushed straw until it breaks. Record the "break-point force" reading on the dial, remove the broken straw and repeat for all 30 samples. Calculate the simple average for all 30 samples and use this average number to read the relative value in the appropriate index table. (Note: If comparisons are being made between locations or times, the straw should be conditioned for at least 24 hours first by storing it in a place that has a standard humidity and temperature. In Russia I was told this is a 60% relative humidity and 20 degrees Celsius, although international standards are 70% relative humidity and 20 degrees Celsius. The strength of flax straw and fiber varies significantly with its moisture content and hence strength readings can be misleading if conditioning is not done first.)

*Straw Color* – Standard straw samples, nine or ten in a set, are kept in a closed box to prevent a change of color due to photo-oxidation or bleaching. When samples are tested, they are compared to the color of the standard straw samples that are kept in the box. New straw samples are prepared every two years by VNIIL (?) and sent to all processing plants. Color is also now judged using color meter KC-3. (NOTE: by changing the wavelength to 364 "mu", the same color meter is used to estimate the lignin content in a sample of straw and hence the fiber quality since the more lignin between the elementary fibers, the more coarse the fiber bundle and the less valuable it is).

*Straw Weight* – Various scales are used. The larger ones have "racks" or small bars attached to both sides of the weigh pan to make it easy to weigh long straw without it falling off the sides.

## LONG LINE QUALITY

According to Dr. Mukhin, the four characteristics of long line that are most important are length, strength, flexibility and color.

*Long Line Length* – Take 30 samples of 25 grams each. Use a special spring loaded pincher device to measure the thickness of the sample starting at one end of the sample and moving to the other end. When the pincher indicates "5", mark this spot and continue on through the thicker (i.e., middle portion) of the fiber sample. When the fiber sample is no longer thick enough to keep the pincher open at "5" or above, stop and measure the distance to the first spot. The length between the two spots indicates the useful length of the fiber sample (i.e., the "useful" length does not include the two fiber "tails" of the sample).

*Long Line Flexibility* – Cut 30 samples of fiber 27 cm in length from the middle of the fiber sample being tested. Put the fiber samples under a special five kilo weight in a conditioning box or room for 24 hours. Take 420 milligrams of fiber from each sample and clamp the sample at its approximate mid-point on the two arms of the Fleximeter GV-2 (3). Release the arms to allow both ends of the flax fiber bundle to fall along index markings along both edges of the Fleximeter. Record the scale readings at both ends of the fiber bundle. Repeat for all 30 samples and take the simple average of all readings.

*Long Line Strength* – After carrying out the just described flexibility test, take the same samples and test them in the dynamometer in the same way as the straw was (see above).

*Long Line Color* – Tests are similar to those done for straw. The samples of fiber being tested are either compared to standard samples (changed every four years) which are kept in a light tight box or analyzed using the color meter KC-3.

*Long Line Yield of Hackled Fiber* – A sample of long line is weighed and then hackled (i.e., combed) by hand or with a small hackling machine (the hackling machine is preferred because it operates with consistent speed and force). The weight of hackled flax is expressed as a percent of the being weight of long line. (NOTE: long line spinners use only hackled flax fibers in the traditional long line wet spinning process so a spinner or hackler wants to know how much long combed fiber will eventually be available for wet spinning purposes).

*Long Line Fineness* – This test is often not done, especially if the sample is put through the hackling machine since the percent of hackled fiber already shows the combined effects of strength and fineness. However, when a separate fineness measure is needed, a fixed weight (420 mg. ?) of fiber is obtained, conditioned and combed with a special fine toothed comb two times. The bundle is then cut and one end discarded. The clean-cut end is then cut again several millimeters from the edge of the first cut. The pieces of fiber that fall during the cutting process are spread out on a dark colored surface and counted. The higher the number of fiber pieces, the finer the fibers in the sample.

TOW (i.e., short fiber) QUALITY

*Tow Trash Content* – Take a 6 gram sample and sort the trash out by hand. Express the weight of trash as a percent of the beginning weight. This is, of course, very time consuming but used for very small samples. If larger samples are being tested, they are weighed and then put in Shive Separator PK-2M. This consists of a rapidly rotating drum that has several rows of pins on which the sample can be spread. The lid covering the drum also has several rows of teeth. When the lid is closed, the drum rotates for a given length of time and the shives fly off the fibers because of the interaction of centrifugal force and the rubbing action of the teeth. The shives fall in a drawer underneath the machine. When the machine is stopped, the shives are weighed and expressed as a percentage of the beginning dirty fiber weight.

*Tow Strength* – The tow fibers are layered onto a long trough-like structure that feeds the fibers between two small-pinned rollers that rotate at different speeds. This roughly combs the fibers and begins to align them to produce a roughly formed "sliver" or continuos strand of fibers. This rough sliver is passed twice more through the same rollers and each time it becomes more even and aligned. After the third pass, the sliver is cut into ten or more 27 cm long sections, twisted a certain number of times and placed in the dynamometer in the same manner as the straw and long fiber, however, when tow is measured the gap between the clamps on the dynamometer are set 7.0 cm apart whereas the gap for straw and long line measurements is set at 10.0 cm. Normally ten samples are taken from a single sample sliver and a simple average of the ten strength measurements is used to estimate the strength of the tow sample in question.

## LABORATORY PROCEDURES FOR PREPARING SAMPLES

Much of the straw produced in various agronomic tests at various locations is sent to VNIIL to be tested. Usually unretted dry straw is sent so that VNIIL can water ret all the samples in the same way and hence reduce the fiber quality and quantity variations that may be caused by different field retting conditions at different locations. Rows of two-meter deep ceramic tiled, vertically oriented tanks were set up to handle many different samples at once. Very small samples are also retted vertically in stainless steel vessels shaped like cylinders closed at one end. Straw is retted in warm water (i.e., 36 degrees Celsius) until hand tests show the fiber is released easily from the shives. After retting the samples are put through a device which rinses each sample with clean water and then presses the wet straw between smooth rollers to squeeze the excess water out of the straw. The straw is then placed on screened drying racks which are stacked about 15 cm apart on a moveable rack holder. The racks of wet straw are pushed into a large drier much like a baker pushes racks of bread into a proofing or conditioning room. After the racks are in the drying chamber, heat and fans are turned on. Racks are pulled out every 10-15 minutes to change the positions of the racks to allow more even drying. It can take one to three hours to dry the straw sufficiently to permit good scutching. Samples are then usually taken into the next room where a commercial scale scutching line is set up. This scutching line has been used continuously for 30 years so that results between years can be compared easily. The line is the same diameter as a commercial one but it has only two turbines instead of four (i.e., it is half as long) so samples travel through faster and it takes less space and electricity than a full-length line. Once the samples are scutched they are taken into an adjoining room where they are hackled by hand or with the miniature hackling machine to allow the calculation of yield of hackled fiber. The hackling machine is preferred because it is more consistent in action and force than human hacklers.

## SOME GENERAL COMMENTS ABOUT AGRONOMIC PRACTISES

-Mr. Ulrich was told that the amount of potash available to flax plants influences the cellulose (and hence fiber) content of the straw. In Russia it is common to add small amounts of zinc and boron and sometimes even copper to fields that will have fiber flax planted on them. Some herbicides affect fiber quality and soil pH can also have an effect on fiber quality and quantity.

-In Russia when the flax is pulled, it is normally "deseeded" at the same time. The seed bolls are normally not dry and hence must be taken to driers and dried before they can be threshed. The uneven seed maturity and uneven or incorrect drying temperatures often lead to seed that has uneven germination and/or vigor. This, in turn, affects the quality of the crop the next year.

-Flax is usually pulled in late August or September however, most of the fiber flax regions in Russia suffer from too much rain in September and October. This often leads to over-retting of the straw. Traditionally, after the straw was pulled it was "tethered" (i.e., loosened from the ground) or turned once or twice to allow it to ret more evenly and to separate it from the damp earth and emerging weeds. After it was retted sufficiently it was often raked into piles by machine and then people would go out in the fields and make loose "stooks" of the straw by loosely bundling the straw so that it could be stacked vertically in piles and left to dry. Once the ground is dry (i.e., heavy rains would make fields too muddy for machinery but humans could walk out and "stook" the flax to dry) round balers are taken out to the field and flax is fed in a roughly aligned manner into the baler. Since the flax is often fed in by hand, the straw is never aligned as well as if the baler had picked the straw up directly off the ground after it had been laid down by the puller. This means that when the bale is unrolled in the processing plant, a higher that expected amount of the fiber ends up being less valuable tow instead of more valuable long line. To overcome this problem, new pullers have been built which leave two v-shaped trenches underneath the flax straw after it has been pulled. This is supposed to allow the straw to dry quickly after the rains stop, with no need for hand labor to build stooks to dry the straw. This will subsequently allow a baler to pick up straw that is still aligned on the ground and produce bales which will produce a higher percent of long line since each bales should have a higher percentage of aligned straw.

-The Russians have been buying some seed from Western European producers of fiber flax seed to try and improve the evenness and emergence of their fields and they suggested that they would also consider buying seed from Western Canada if we could compete price and quality-wise with European suppliers of fiber flax seed.

## COMMERCIAL SCALE PROCESSING PLANT

-One morning Mr. Ulrich was taken to see a commercial flax fiber processing plant 15-25 km from Torzhok. He was told there are over 300 such processing plants throughout Russia. One of the most concentrated flax regions is the Trev Oblast which is the Oblast that that surrounds Torzhok (looking on the map, the Oblast may be roughly 150 km by 150 km). It has 30 flax fiber processing plants, however, last summer there was a drought in this Oblast and little herbicide available to control weeds. The fiber flax crop was short and weedy so it was abandoned and not one of the 30 processing plants is operating in the 99/00 season.

The processing plant we visited was locked. When the manager came he opened the doors and showed us around. It obviously had been shut down not long ago as the machine parts were still shinny with wear. All equipment was of Russian design and construction but the principles of the machines were similar to those found in western European flax plants. There were two scutching lines and two tow cleaning lines with accompanying bale-pressing machines at the end.

The processing plant had straw and fiber testing rooms complete with two miniature breaking-scutching machines (SMT-200) identical to the one in the VNILL lab. We were told that when a wagonload of bales comes from a farm, a typical bale in a wagonload is unrolled and 10 one kilo samples are taken out. Tests are then performed on each one kilo sample and then results of all ten samples are averaged to estimate the properties of that bale. This is then used to determine the relative value of the bale. If bales in a wagon are of quite different types, then tests are done on a typical bale of each different type.

## Friday, March 24th

-Mr. Ulrich was taken for a short tour of the Biotechnology Section VNILL since the head of this Section, Dr. Alexy Poliakov, had, some years previously, spent several months in Saskatoon with Gordon Rowland and Al McHughen of the Crop Development Center in Saskatoon.

-In the afternoon Mr. Ulrich traveled three hours back to Moscow airport and left for Frankfurt and Stuttgart.

## Saturday and Sunday, March 25th and 26th

-Mr. Ulrich spent the weekend in Stuttgart. He did notice that in the big department stores and women's clothing stores, there was a good selection of linen and linen blend clothing for sale, especially in the spring and summer collections, however, table and bed "linen" made from linen or linen blends was difficult or impossible to find. Roughly half of the linen and linen blend clothing carried labels that basically said something like the following: *This product is made from linen, a natural fiber that has a long and noble tradition. The fabric in this product has imperfections and it wrinkles but this is how you can know for sure that it is a really natural product.*

## Monday, March 27th

-Mr. Ulrich went on the subway out to Stuttgart airport and met Chris Hale and Terry Boehm who had just flown in from Canada. Once the problem of lost luggage was settled, the three of us took the subway into Stuttgart and then a slow train to Ruetlingen (less than 60 km south of Stuttgart) where we were met by Kai Nebel, a senior research scientist at Institute of Applied Research (IAF), who took us to our hotel. From the hotel we were taken to IAF, which is in a large building situated next to the Ruetlingen School of Textiles, which is, in turn, part of Ruetlingen University.

-The International A Fund was set up about 15 years ago by the German government in an attempt to enable farmers to reduce their dependency on growing cereal and oilseed crops by developing new technologies that would make natural fiber crops like flax and hemp once again attractive to grow and process. The original mandate of IAF called on it to do only "pre-competitive" R&D but, over time, IAF has evolved to the point where it does roughly 50% pre-competitive (i.e., public) R&D and 50% privately contracted R&D. It claims to be one of the few internationally reputed research institutes in the field of biobased materials, mainly focused on the preparation, analysis, finishing, and application of natural fibers and polymers.

-For most of its existence, the IAF has been headed by Dr. Rudolf Kessler, who formerly worked in the corrosion chemistry section of the R & D labs of Mercedes Benz.[7] It was Kessler's view that natural fibers have both positive and negative attributes. The positive attributes like environmental friendliness, comfort, pleasing appearance, etc. are very good but they are not, in themselves, sufficient to overcome the resistance of large manufacturing concerns (e.g., Mercedes Benz) to using natural products unless some of the negative attributes are tackled. One of the main negative attributes of natural fibers is the relative inconsistency of their physical and chemical characteristics compared to synthetic fibers. To this end, Dr. Kessler devoted much time and money into finding out what physical properties are important to measure and then how can these properties be measured quickly, reliably and cheaply. The ultimate goal of such rapid measuring systems is to allow processing machinery to be continually and automatically adjusted to compensate for uneven straw quality and/or to allow the blending of different lots of fiber so that large batches or lots of fiber can be produced that will have consistent properties and hence be much more acceptable to industrial users.

To this end, IAF has carried out an extensive amount of work with InfraRed, Near InfraRed, Ultra-Violet, florescence and ultra-sound to measure fiber properties. They have found that the two major determining factors which affect flax and hemp fiber quality and quantity are the degree of maturity of the straw and the degree of retting and this is especially so when the fibers are to be used for textiles. The degree of maturity can be found by measuring the degree of filling of the "lumen" or hole within the fiber walls. As the straw matures, the lumen fills up and makes the fiber cell more solid; this increases the weight and strength of the fiber but decreases the fiber fineness. In addition, as the straw matures more lignan is deposited. Lignan resists retting and this, in turn, means that as the straw matures, it becomes increasingly difficult for the retting process to produce finely divided fiber bundles.

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[7] The IAF has a policy of only hiring people for tenured positions who have had at least five years experience working for private enterprises. They also have a policy of not keeping non-tenured people for more than five years so that they always get a new flow of ideas and expertise.

The IAF have a specially constructed microscope which combines InfraRed and Near InfraRed Technology with a microscope to permit unusual images of straw and fiber to be made. They are also starting to use an "atomic-force" microscope which will allow even more unusual images and studies to be made. Dr. Kessler said he expected NIR will be the first technology that will be adopted to measure straw and fiber "in-line" and that it will become significantly cheaper in a year or two, however, in the longer run, he expects that most in-line measurements will be done using ultra- violet technology because new developments are showing that UV measuring systems will likely cost only half as much as NIR systems. (i.e., the German optical industry has stated a target price for UV measuring system in the range of US$30-40,000 [C$44,000 – 59,000] whereas the target price for NIR is about US$70,000 [C$103,000] and some have even said that UV systems may eventually cost only ten percent of a NIR system, although the UV system may be not quite as accurate).

Kessler said that the percentage of lignan surrounding a fiber dictates how the fiber is treated and valued. On one hand, we have wood with a lignan content of greater than 30%. The fibers produced from wood (usually for paper or absorbency products) are low in value and processed with machines that have a high throughput. On the other hand, the fibers from cotton have less than one percent lignan, have a high value and are processed on machines with a low throughput. Bast fibers, like flax and hemp, are somewhere in between since they have a lignan content of 5-10%, however, the value of flax and hemp fibers has a tremendous variation from as low as wood fibers to much higher than cotton. Depending on the end use, flax and hemp either have to be treated more like wood or more like cotton but they really need a separate and distinct system rather than a modified wood or cotton system.

Tuesday, March 28th

-Kai Nebel took us on a tour of the many testing and processing facilities that are available at IAF and at the adjoining Reutlingen School of Textiles. These included everything from labs which test the chemistry of fibers to large workshops that have full scale spinning, weaving, knitting, bleaching, dying, printing and finishing equipment for small batch processing, testing and teaching purposes. The following were some of Kai's comments with regard to flax and hemp:

When flax fiber fineness is measured using an airflow system, the air flow system for measuring the fineness of wool gives more consistent results than the airflow system for measuring cotton. This is largely because the wool device (i.e., the Wira system) uses a bigger sample size than the cotton device. Since flax fibers are intrinsically more heterogeneous than cotton fibers, the larger sample size associated with the Wira system will tend to give more consistent results when flax fibers are tested in it.

-The Pressely manual device to measure strength gives reasonable results for cotton and wool fibers but gives a large variation of results when bast fibers are tested. This could be because bast fibers appear to be able to more easily slip out of the clamps than cotton or wool which have single fibers rather than bundles of fibers. For strength measurements, they prefer the Instrom system because they clamping system is reasonable good and it is easy to change the "span length".

-Hemp fibers are more variable than flax fibers because there is more intrinsic genetic variability in hemp seed and more variability in the height of hemp plants that are supposed to be genetically the same. Since hemp is much taller than flax there is much more difference in the type of fibers between the top and the bottom of a single hemp stalk. This is then compounded by the fact that plants which are genetically the same will have different heights even though they are growing side by side (part of this is because the female plants get taller than the male plants but also because they appear to be very sensitive to nutrient variability in the field.)

-Nothing can be made from industrial hemp that cannot be made from flax except hemp hurds. (At the present time, hemp hurds are more in demand for animal bedding than flax shives because the hurds have been promoted more).

-In the UK there is a bio-composites center that has been setup to develop new ways of processing natural fibers and finding new uses for natural fibers in composites.

-In car part factories in southern Germany flax fibers are being purchased for roughly DM1.00-1.30/kg (C$700/tonne – 910/tonne) and for about DM2.00/kg (C$1,400) if the fibers are in the form of a lap (i.e., rolled mat).

The IAF engages in contract R&D work for German and foreign companies; they prefer longer term contracts that last for six months or more.

-Kai Nebel of the IAF felt that, of all the properties of flax straw, the most important one is the yield of useful fiber per kg of straw.

-The ITL in Paris does flax related research but does not share or publicize most of their results.

### Wednesday March 29th, 2000

-We went to visit Helmut Pill who does consulting work with wet-laid non-woven fabrics. Mr. Pill also makes laboratory scale machines (300-1000mm wide) that can be used to make wet-laid non-wovens and paper. These machines are often used by laboratories or by small companies to test and make-up batches of wet-laid non-woven materials that involve new, recycled or traditional fibers that have been treated in new ways.

Mr. Pill pointed out that during the formation process wet-laid non-wovens use much more water than is used during the paper formation process. This is because the long fibers must be freely swimming in water when the wet-laid mat is being constructed. When his machines are used for making paper, much less water is used, only very short fibers are used, and the screen is kept flat, instead of being inclined.

-Mr. Pill pointed out that the wet-laid process is used when the strength of the non-woven fabric is important but, in general, it is a more expensive process than a air-laid system, however, air-laid systems are usually only used where strength is not important (e.g., tampons).

-It takes about four months between the time one of Mr. Pill's machines is ordered and the time it is ready for delivery.

-Many potential customers send Mr. Pill one or two kilos of fiber and ask him to make samples with a given weight per square meter, so they can take the samples that he produces and have it tested by potential users (e.g., if you wanted 20 square meters of a sample fabric with a density of 60g per meter squared you would need 1.2 kilos of fiber).

-Mr. Pill's machines are roughly DM 250,000 (C$175,000) and higher, depending on the width and the machinery that is added at the front and the back of his machine.

-A small continuous paper making machine could be made by putting refiners in the front of his machine and roller dryers at the back of the machine.

-We took a train from Reutlingen to Stuttgart and then a train to Mulch (approximately three hours time).

-At Mulch we were met by a representative of BAFA, a processor of hemp. BAFA buys baled hemp stalks from farmers and processes them into hurds and fiber. About 50% of the fiber is then sent to one of the four companies in Germany that make insulation from flax and hemp fibers. The other 50% of the hemp fibers are sent to companies that are making plastic composites mainly for the automobile industry (e.g., the Mercedes S series now has plastic composite panels made with a combination of flax, hemp, and sisal).

-Most of the hemp hurds are sold for bedding but some is now being sold to a company that makes a board from hemp hurd flour that is pressed without any binding agent or resin.

-The German car industry started using components made from natural fiber and plastic composites in 1996. In that year they used about 4,000 tonnes of natural fiber; by 1999 this had grown to 14,000 tonnes (of which 1,800 tonnes were hemp fibers).

-Hemp fibers are being sold for industrial use at about DM1.00/kilo (C$700/tonne) and 20 kilo(?) bales of pressed clean hurds are selling for about DM10.00 (C$7.00).

-The average hemp yield is 6-10 tonnes of straw (dry weight basis) per hectare with 20-25% fiber content. BAFA pays farmers DM150/tonne (C$105) of straw and farmers receive an additional subsidy from the EU Government of DM1,300/hectare (C$910/hectare or C$370/acre).

-In the processing plant about 10% of the weight of the straw is lost in the form of dust.

-The processing plant can process, at the moment, about 1.5 tonnes of straw per hour and hence the straw from 750-1,000 hectares can be processed per year.

-Since it's startup the plant has spent roughly DM3,000,000 (C$2,100,000) on equipment but if it built another plant it could reduce the equipment cost because it now knows which equipment is most cost effective.

-The three biggest technical problems that farmers and BAFA have faced are:

1) how to grow hemp;
2) how to set up machinery to process hemp; and
3) how to develop markets to sell hemp products into.

-Consolidated Hemp Processors from the USA put money into the BAFA facility but they now want their money out because of their financial problems in the USA.

-We spent the night in a little hotel at the edge of the Black Forest near the town of Mulch.

### Thursday March 30th, 2000

-We took the train to Koln, Brussels and then to Lille (which is almost on the border between France and Belgium).

-After arriving at Lille at about 5pm we checked into the hotel that had previously been booked for us by Saneco.

### Friday March 31st, 2000

-We were picked up at our hotel by a staff member of Saneco and taken to their offices for introductions and a brief introduction to the company.

-Saneco is one of the largest French fiber brokerage companies that deal in flax, hemp and ramie fibers and they have been in existence for roughly 60 years. They have representative offices and/or sales offices in Western Europe, Eastern Europe, China, South America, Southeast Asia, and North America, and have several joint venture operations in France and Lithuania.

-Textile mills in China are one of the most rapidly growing markets for fiber sourced by Saneco. Twenty years ago there were less than 100,000 flax spindles in China and roughly a dozen companies, today there are more than 400,000 flax spindles in 36 companies.

-We were briefly shown the Saneco logistics department and taken to the sample room where large numbers of flax samples of flax long line, tow and cottonized flax samples are kept as a record of fibers that could be or have been bought and sold.

-In the afternoon Benoit Dalle, the President of Saneco, took the three of us plus his financial officer to Lin2000, a flax processing cooperative at Granierville about 1.5 hours southwest of Lille.

-While the Saneco officials were having a meeting with the board of directors of Lin2000, one of the staff members took us on a tour of the Lin2000 facilities.

-In 1999 the fiber flax straw crop was particularly good with average retted straw yields of more than 7 tonnes/hectare (of this 7 tonnes about 1 tonne is seed yield).

-Lin2000 has started their own fiber flax breeding program and they have released one variety called Diva.

-Most of the seed for farmers in the Lin2000 coop is produced under contract with farmers in the Champagne area of eastern France where seed yields are roughly 2 tonnes per hectare. The flax in this area is allowed to get fully ripe before the seed is harvested the straw which remains is baled in an under retted state and is processed for paper or low-grade industrial use.

-Growth regulators are often used in members' fiber flax fields to prevent lodging.

-Lin2000 has an older (more than 30 years) scutching mill with 3 lines. They have recently built a hackling plant with Italian, French and Belgium equipment. On the day of our visit the scutching plant was not running but the hackling plant was.

-The structure of Lin2000 is similar to what we would call a 'new age cooperative'. To become a member of the coop group, a farmer must put in an equity contribution equal to roughly the revenue from one hectare of fiber flax times the number of hectares he is willing to commit to fiber flax every year. Commitments must be for three to five (?) years. A farmer can sell or purchase shares in the cooperative providing the commitment to grow fiber flax is attached to the shares.

-In the late afternoon Mr. Dalle took us from Granierville to Charles De Galle Airport near Paris. From the airport we three Canadians caught the train into Paris and found our little hotel that had been booked by Saneco that morning.

## Saturday April 1st, 2000 & Sunday April 2nd, 2000

-Each of us spent our time in Paris in his own way
-Sunday evening we took the TGV train back to Lille

Monday April 3rd, 2000

-Had a short meeting with Mr. Dalle.

-90% of the fiber flax crop has already been seeded. Generally farmers in southern Flanders start seeding in mid to late March while farmers in the northern part of Belgian Flanders seed in mid April.

-In general early seeding gives a higher percentage of long line fiber but a lower straw yield. Belgium farmers generally like higher straw yields so they seed later but the quality of their crop is not quite as good as the French crop.

-There are two hemp processors in France; one processes roughly 5,000 hectares, the other processes about 2,000 hectares.

-The EU has stated its intention to change the subsidies paid on flax. If this new plan is implemented it will not discourage long line production but it will discourage flax that is grown for seed and tow production. Thus the area planted to flax in France and Belgium is not expected to change much but the area planted to flax in the UK and Spain is expected to drop significantly. The decision to implement these changes was not made in time for the crop of 2000 but it is likely to be implemented for the crop of 2001 and thereafter.

-Companies using flax and hemp fibers in plastic composites for car parts have found hemp to be less attractive than flax. This is because hemp hurds are, in general, much bigger than flax shives. For industrial uses, flax and hemp fibers are not generally 100% clean fiber because this level of cleanliness makes the fiber too expensive for industrial users. Since hemp hurds are bigger than flax shives, there is a greater chance that a large hemp hurd will cause a defect in a plastic composite containing hemp.

-About 45-50% of the cost of making a kilo of yarn from long line flax comes from labor cost and thus there is pressure on Western European spinners of long line flax to move their spinning operations to countries with cheaper labor costs. For example SFL, a large French spinner, is making a joint venture in China; Safilin, another French spinner, is relocating most of it's spinning operations to Poland, and Linficio, the biggest Italian flax spinner, has relocated some of their spinning operations to Tunisia.

-In Paris there is an association of cooperatives called FESTAL. Most of the fiber flax processing coops belong to this association and if we are interested, this association can give us much information on how fiber flax cooperatives are organized and operated.

-In 1999 the yield of straw (7,000 kilos) was higher than average (6,500 kilos) and the average yield of long line (18.5%) was higher than the long-term average (17%). Thus, in 1999, the average hectare of fiber flax produced 1,300 kilos of long line and 600 kilos of re-scutched tow. Flax fiber prices have risen in the last six months and long line can be easily sold for FF12 per kilo and re-scutched tow FF2 per kilo. This means that the average hectare of fiber flax in 1999 produced fiber products (not counting seed or shives) of FF16,800 or roughly C$4,200 per hectare or C$1,700 per acre (this is more than 10 times the gross income the average farmer in Saskatchewan received last year from one acre of flax!).

-The world market for flax, hemp and kenaf is growing by roughly 20% per year due to the application of these fibers in industrial uses like plastic composites, but the growth in the North American market is the most difficult to predict.

-Kenaf can be cleaned easier than hemp and will likely be a strong competitor for flax and hemp in the North American market for industrial fibers. The market for flax fibers used for industrial purposes (i.e., not for paper or textiles) is presently 12-15,000 tonnes per year, but by the year 2005 this could be two to three times as great. At the present time, 50-80,000 tonnes of flax fiber are used in the USA for specialty paper, about 50,000 tonnes are used in the EU and about 50,000 tonnes are used in other parts of the world.

-With existing technology the market for textile grade flax fiber is not expected to change much in the future however volumes could increase significantly if cottonized flax becomes cheaper to produce and/or if knitting technology using flax fibers continues to improve.

-Mr. Dalle thinks that eventually there maybe many small flax fiber-processing plants (i.e., less than 1,000 tonnes per year of fiber) established in the flax growing regions of North America. Such small processing plants would help to reduce the cost of straw transport and would be easy to organize. Such plants could simply import European tow cleaning equipment and start using it, but there may not be an advantage to be the first company to start processing (i.e., it maybe a disadvantage to be the first company because you will make mistakes that subsequent companies could avoid).

-Mr. Dalle estimated present market for cottonized flax is 20-30,000 tonnes at prices ranging from US$1.20 to US$3.50 per kilo.

-In the afternoon we visited a newly constructed flax scutching plant operated by Patrick Vanhersecke near Millam about an hour from Lille. This plant cost roughly FF9,000,000 (C$2.4 million) and can process 2,200 kilos of retted straw (including seeds) per hour.

Tuesday April 4th, 2000

-We were taken to visit the Van Robaeys Freres flax processing plant at Hondschoote in a rural location about one hour from Lille. This plant is said to be the largest flax scutching plant in France with five scutching lines in operation and the processing of straw from 4,000 hectares per year. It is also the biggest private scutching mill and the biggest cottonizer in France. It employs 120 people, operates 3 shifts a day and processes 150 tonnes of straw every 24 hours. In addition to scutching and cottonizing, the plant also produces fiber mats for the automotive industry and has total sales of about FF100,000,000 (C$27.0 million) per year.

-In 1999 the crop was very good with average retted straw yield of 7,300 kilos per hectare and 20% long line. They use 12 different varieties and they have found different varieties have advantages in different areas. The income from fiber flax must compete with the income that can be earned from wheat, corn, sugar beets and barley.

-Seeds are purchased from the Netherlands and France and are usually second and third multiplications.

-Farmers usually receive partial payments in September, February and the following summer.

-In general the higher the fiber content, the coarser the fiber and the more yellow (i.e., the more mature) the flax, the longer to ret, especially the "feet" of the flax plants.

-In this part of France an average hectare of farmland costs FF30,000 (C$8,100) per hectare to buy and FF5,000 (C$1,350) per hectare to rent for one year (including storage and fertilizer).

-It costs roughly FF10,000 - 12,000 (C$2,700 – 3,240) per hectare to produce a fiber flax crop.

-In 1999 flax fiber prices were high so farmers could sell their flax straw for FF1.80 - 2.00/kilo (C$480 – 540/tonne) but in a poor year this can drop to FF1.10 - 1.20 per kilo (C$300 – 320/tonne).[8]

-Over time new varieties of fiber flax have tended to have a higher percentage of fiber but a coarser fiber. Since the fiber is coarser, it is more difficult to cottonize and it is common now to have a cottonized yield of 70% compared to a cottonized yield of 80% when older varieties were used.

-Flax production in Spain has been growing rapidly to take advantage of the flax subsidies. In 1990 Spain had only 2,000 hectares of flax but in 1999 Spain had 120,000 hectares of flax.

-We were taken on a tour of the scutching lines, sample room and fiber warehouse but were told the cottonizing line was being repaired so we could not see it. We were also not taken to see the part of the plant that was producing fiber mats for cars. The scutching lines collect data on variety, fiber yields, types of fiber, moisture content, color, etc. from each batch of straw. They also measure how fast it took to process an equivalent amount of straw from each batch of straw.

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[8] There is approximately FF3.70 - 4.00 in one Canadian dollar; the conversions shown in brackets use the rate FF3.70 = C$1.00)

-From Lin2000 we were taken several kilometers away to Decock SA, a family run business that specializes in reprocessing better grades of tow into sliver that can be spun.

-The Decock company purchases bales of high quality tow, puts them through a bale opening system which opens the fibers sufficiently so they can be carded and made into rough sliver. The rough sliver is then combed one to three times and twice put through drafting machines which help to regulate the density of the sliver. Once the slivers are combed and regulated they are coiled in drums and pressed very tightly for shipment. In theory the combing machine can produce 40 kilos per hour of combed sliver but Decock personnel said that, in reality, production is about 10 kilos an hour if one counts the time taken up with breakdowns and repairs. The newest combing machines are rated at 80 kilos per hour and cost FF500,000 - 600,000 (C$135,000 – 162,000).

-Combing is much slower than hackling but combing can utilize high quality flax fibers of assorted lengths whereas hackling can only utilize long fibers.

-In the early afternoon we drove to Kortrijk, Belgium but had difficulty finding lunch as we had arrived in Kortrijk after 2:00 PM and almost all the restaurants close at 2:00 PM and reopen at 5:00PM.

-We stopped in briefly at the firm of Depoortere, a third generation family run business that makes flax pullers, deseeders, turner/deseeders and scutching lines for long line flax fiber production. Since flax fiber prices are now at historical highs, the demand for new Depoortere equipment has risen dramatically in the last six months and Depoortere is finding it difficult to hire good machinists to keep up with demand.

-The company has started making a double row turner/deseeder with a seed cleaner and a cab. They have made four of these machines to date and the selling price is US$220,000 - 240,000 (C$324,000 – 353,000).

-The company has also started making some parts that are used in the LaRoche hemp cleaning machines.

-From the Depoortere facility we traveled about 20 minutes to the flax museum in Kortrijk where we had a brief but interesting time looking at the many devices and pieces of equipment that have been developed and used over the years to produce fiber, shives and seed from flax.

-The flax museum has recently opened a new building devoted to the history of linen and lace but we did not have time to visit it.

-The flax museum has re-issued a book in English called 'Flax in Flanders Throughout The Centuries'. It is full of pictures and text describing the history of the flax fiber world

in France and Belgium. This book can be purchased on the 'net' by going to a website operated by 'The LinenHouse' (www.linenhouse.com).
(On his arrival back in Canada, Mr. Ulrich ordered this book over the Net and received it by courier from Brussels in less than two days!)

-From the flax museum we drove about 15 minutes to Charle & Co., a family run company that has been building flax and hemp tow cleaning equipment for several generations.

-The Charle & Co. has started a joint venture with a German company called Temafa. Between these two companies they make a line of machinery which can open, clean, blend and produce non-woven mats. Their machinery can open 2.0 - 2.5 tonnes/hour of fiber in a very regular manner but if stops and breakdowns are counted the average is about 1.5 tonnes/hour. A complete line with opener, shakers, baler, dust collection system, electrical system and a duvex machine (cleans fiber out of shives), would be approximately DM3,000,000 (C$2,100,000) and it would need to be in a building about 60 meters by 30 meters and 7 meters high.

-Their 'LIN opener' system splits open fiber and shortens it to make it ready for use in non-wovens.

-In 1999 they installed a plant in Sweden to process both green (i.e., non-retted) and retted flax for non-woven uses.

-From their experience in Spain they feel that strong sun drives the oil out of the fiber in flax stems and thus fiber grown from flax grown in sunny locations tends to feel much drier than flax grown in cloudy locations.

-Hemp dust is now being used by fisherman to attract fish.

## Wednesday April 5th, 2000

-We took the TGV train to Lille to Paris (1 hour) and changed trains to go from Paris to Rouen (2 hours) where we were met by Guy DeHondt and his son who treated us to a wonderful lunch in a small village, and then drove us about one hour to a flax fiber processing coop in Goderville. The Goderville coop has a relatively new scutching facility with several scutching lines. Each scutching line is equipped with a new DeHondt equalizer/roller for scutched fiber. These equalizer rollers are positioned at the end of the scutching line and take the scutched fiber as it is being processed and slow down or speed up the roller mechanism so that the density of the fiber being rolled up is the same throughout the roll. The scutched long line fiber is rolled between layers of plastic and can be later unrolled and immediately loaded into a hackling machine with little or no labour. An equalizer/roller system costs roughly FF750,000 (C$200,000) and can only be used if the scutched fiber being produced in very even in quality.

-Mr. DeHondt estimated that a long line processing plant including building, electricity, dust system, one scutching line, four Charle tow cleaning systems, etc. would cost about FF15,000,000 (C$4,000,000) in France at this time (this does not include the cost of special field machinery like pullers, turners and balers)

Thursday April 6th, 2000

-Went on the train from Lille to Anthwerp, Rotterdam and finally Wageningen in the Netherlands.

-From Wageningen station we took a long taxi to the large campus that makes up the University of Wageningen and a large number of agriculturally related research institutes.

-We met Martin van der Oeven who Mr. Ulrich had previously met at an FAO flax meeting several years ago. We were then introduced to Martin Snijder and Hariotte Boss who work at the Agrotechnological Research Institute (ATO-DLO) , a research institute that works with agricultural fibers.

-The ATO-DLO has carried out a wide range of fiber related work, especially in the areas of new products. They have, for example, worked on fully decomposable plastics and on a process to continually extrude bast fibers and plastic.

-They have found that finer fibers generally produce stronger composites and hence plastic composite makers will pay more for finer glass or natural fibers than they will for coarse fibers.

-Chalk is often added to glass fibers to change their stiffness to suit the type of composite they are being used in.

-The ATO-DLO has developed a new process to improve the properties of flax fibers.

-They did some trials with chemically pulped flax fiber from Spain but these fibers proved to be too expensive for the application. Clean flax fiber for the automotive industry should cost not more than US$0.50-1.00 per kilo (C$340 – 680/tonne) or users will use non-flax fibers.

-The flax fibers they have seen from DuraFibre in Canada can now only be used in the rougher composites because the fiber is not fine enough for high-end plastic components.

-In general flax, kenaf, and jute are the best natural fibers for industrial uses and hemp will give roughly 80% of the performance of these three fibers when used in most industrial applications.

-Jute is cheap and has good properties so it will be a strong competitor to flax in many industrial applications.

-They have tried using flax fibers alone or with plastic fibers to make pallets, trays, boxes, garden furniture, household wares and a substitute for wood.

-Flax shives are being used as a filler in plastics. It will stiffen the plastic and reduce the amount of plastic resin that needs to be used but it will not make the plastic stronger. In these instances flax shives are competing with chalk, carbon black, and wood flour - all products which have a low value per kilo.

-The ATO-DLO is now part of a new foundation that does agriculturally oriented research. The ATO specializes in post-harvest R&D and deals with:

1) renewable resources;
2) fresh agricultural products and their preservation; and
3) food processing.

Friday April 7th, 2000

-Met with Ed DeJong who works in the pulp and paper section of ATO_DLO. This section has 25 people who carry out a variety of work in the areas of making pulp and paper from traditional and non-traditional sources of cellulose.

-One of the projects they are presently working on involves a closed mill technology (10-30,000 tonnes per year) for pulping and the production of lignins that can be used in cement, adhesives and feed. This particular technology cannot use wood because pulping wood requires the addition of sulfur, which will contaminate the lignin.

-Their research has indicated that, for pulping purposes, flax fibers with a high percentage of shives would be worth about US$200 per tonne (C$295) but flax fibers with no shives would be worth about US$700 (C$1,030) per tonne.

-We were shown samples of wetlaid and drylaid non-wovens made from a specially treated flax fiber that could be used for wiping pads and rags.

-For this end use, they could pay up to US$1,500 (C$2,200) per tonne but the flax would have to be available in large and consistent batches and would have to be of a quality similar to hackled tow.

-Mr. DeJong said the non-woven fiber market is growing 8-10% per year, and the Dutch market alone is worth about DG1.8 billion (C$1.4 billion). A plant could be set up to process flax fibers for this high end non-woven market but it needs a commitment from at least three big end users for several years before investors are willing to spend money on a large scale plant.

-A non-woven wiping pad made from flax would be stronger when wet than if it were made from viscose, the traditional source of much of the fiber used in wiping rags. The flax fiber would also be much more environmentally friendly than viscose.

-We also met with Jan van Dam who is the program coordinator for the fiber and cellulose section.

-There is a Dutch company that wants to use much more cottonized flax but needs to have a reliable large supply and wants to be able to quantify the characteristics of the fiber very quickly. In the EU, flax fiber is not available in the kind of quantities that big companies are used to purchasing. In addition, in the EU, flax fibers are often perceived to be too expensive relative to other fibers. This is because the cost of producing flax fibers in the EU is very high because of high land, labor and machinery costs. Large companies are also reluctant to use flax because of the lack of a consistent grading system across the EU.

-For high end non-wovens the fiber characteristics with the most importance would be fineness, strength, fiber length distribution and crystallinity (i.e., the more crystalline the fiber is the less absorbent it is).

-ATO-DLO research has shown that flax fibers used directly as a geotextile (e.g., a flax mat which covers a road embankment) degrades too fast in the wet conditions of Holland, but it is possible now to make it last three times as long if it is treated with an environmentally treatment. Both flax and jute degrade quickly in Dutch conditions because both are sensitive to light and moisture. Coir (i.e., fiber from coconut husks) lasts much longer as a geotextile because it is not sensitive to light.

-There is a potential for improved natural fiber geotextiles to replace synthetic geotextiles because many synthetic geotextiles now cost over DG30/meter square (C$21.00).

-The ATO-DLO has data to show that flax insulation is just as good an insulator as glass fiber and rock wool. They are now working on environmentally chemicals to give fire retardant properties to flax insulation.

-They have done some work with flax fibers in concrete and in bitumen and they have found that in concrete and bitumen roads the fibers help the surface last longer and allow surface water to drain away more easily. They also did work with putting flax in concrete for floors and in making concrete/asbestos sheets for walls. In some applications with concrete, the flax fibers must be given a chemical treatment before mixing it with the cement.

-Mr. Van Dam suggested that a "start up" fiber lab should have at least the following types of equipment: 1) assorted fiber extraction equipment for both extraction of parallel fibers and jumbled fibers, 2) strength testing equipment, 3) fineness measurement equipment, 4) some chemical testing equipment, and 5) a microscope.

-We were taken on brief tours of the plastic composites lab, the pulp and paper lab and the general fiber lab.

-This ended our formal fiber related tour in Europe.

-Mr. Hale traveled to Germany to visit friends before going back to Canada. Mr. Boehn and Mr. Ulrich spent a day in Amsterdam before journeying, respectively, to Canada and South Carolina.

Saturday April 8th, 2000

-Mr. Ulrich and Mr. Boehn in Amsterdam

Sunday April 9th, 2000

-Mr. Boehn flew back to Canada and Mr. Ulrich flew to Washington D.C. and on to Greenville, South Carolina where he was met by Linda Braun of SaskFlax and driven to Clemson, South Carolina (about 40 minutes southwest of Greenville).

Monday April 10th, 2000

-Ms. Braun and Mr. Ulrich attended a flax fiber related conference called 'Fiber Flax Processing For Applications In Textiles And Composites' sponsored by the Center for American Flax Fiber and held at the Madren Center of Clemson University in Clemson, South Carolina.

-After registration and introductions, the conference consisted of a series of presentations, panel discussions and questions and answers. On the first day of the conference we heard presentations and discussions of progress being made on ASTM flax standards, current research projects being done at Clemson University and the USDA facility at Athens, Georgia in regard to flax fibers. We also had presentations by several European and American equipment makers on equipment they have or could make for flax and flax fibers. There were also discussions on possibilities of flax in textiles. Much of this research revolves around trying to find a cheap and consistent way to produce cottonized flax using enzymes.

-In the evening there was a formal dinner and several participants, including Mr. Ulrich, had small displays of products that can be made from flax.

Tuesday April 11, 2000

-We had presentations by several individuals involved in processing or manufacturing flax fibers for use in plastic composites. This particular market appears to have considerable potential for growth but further research needs to be done to establish how best to use flax fibers in making various types of plastic composites and how to grade the fiber and/or straw before it is used in the composites. The quantification of fiber characteristics (i.e., grading) was seen as an extremely important activity to enable flax fibers to be marketed to large industrial users who are used to buying synthetic, cotton or wood fibers with measured fiber properties.

-In the afternoon we were taken on a brief tour of the USDA-ARS spinning lab near Clemson University. This laboratory has a wide assortment of testing instruments and commercial scale fiber opening, cleaning and spinning equipment. The mandate of this lab is to continually carry out research that will allow American spinners of cotton to become more efficient and/or cost effective in their operations. The spinning lab has a new director and money has been allocated to do some spinning research with cottonized flax.

NOTE: We were given Conference Proceedings when we registered and Mr. Ulrich and Ms. Braun can make them available to anyone who wishes to view them. They are full of both technical and general information on flax fiber processing systems, enzyme systems, costing and performance information from a major American plastic composite maker who is using flax fibers, etc.

Wednesday April 12, 2000 to Friday April 14th, 2000

-Linda Braun flew back to Canada on the 12th.

-Mr. Ulrich spent these three days:

- exchanging ideas with Roy Dodd, the main flax fiber research person at Clemson.
- collecting some information from the Clemson library
- visiting several used textile machinery salvage operations
- visiting several companies that make wide selections of fiber "aprons" used in transporting fibers and metallic clothing used in fine fiber cleaning machines.

Saturday April 15th, 2000

-Mr. Ulrich flew from Greenville to Washington to Toronto to Saskatoon.

# APPENDIX E

# FORUM REPORT:

# Growing a Value-Added Crops Processing Industry in Saskatchewan

PAMI

October 28, 1999

# Forum Report: Growing a Value-Added Crops Processing Industry in Saskatchewan

Date: October 28, 1999

Location: PAMI
Humboldt Saskatchewan

Participants:
21 stakeholders and industry builders representing private sector, university, economic development, provincial and federal agriculture groups.

## Objectives:

- Discuss the future of value-added crops processing.
- Discuss how PAMI's new Crops Processing Development Centre (CPDC) might fit into an overall strategy to help farm producers and industry diversify the agriculture economy of Saskatchewan.

## Summary:

Forum had these discussion points:
- Feedstocks
- Process opportunities
- Markets
- Champions

## Feedstocks:

- Short term concentrate on straw and chaff from currently grown crops with most important being flax, wheat and barley straw.
- Efforts made to utilize whole plant not just seeds.
- Consensus that straw burning will be eliminated.
- Potential crops production for energy use should not be ignored.

## Markets

- Green movement is major driver of crop utilization efforts and trend is expected to increase.
- Aging baby boomers hold majority of financial resources. Globally world standard if living is improving.
- Will be more demand for adhesives and resins derived from plants.
- New products should initially target niche markets rather than competing with high volume commodity products.

## Process Opportunities (Current/Potential) identified:

- Size reduction, cleaning, sorting, drying, decortication, conditioning, blending, extrusion, colour sorting, densification.
- Action suggested: PAMI will direct its energies toward primary processing and focus on equipment for size reduction, densification and straw length.

## Champions:

- Individual(s) with established record in leading innovation or small group with a vision and a commitment to succeed.
- Require a facilitator to move industry forward.
- Establish cooperative to represent Agro-fiber industry and use it to promote product, regulatory, standardization and other research.

## Forum Conclusions:

- Flax - clear priority for further value-added feedstock development.
- Environmental issues and livestock key market drivers.
- Animal feed and fiber processors surfaced as industries presenting the greatest process opportunities.

# Appendix F

## Agrifiber Technical Discussion

## SRC visit to ARC

January 26, 2000

## AgriFiber Technical Discussion

**Date:** January 26th

**Location:** Alberta Research Council
Edmonton, Alberta

### Participants:

Stakeholders and industry builders representing private sector, university, economic development, provincial and federal government ag/science groups. Trek was sponsored by SRC and SAF.

### Objectives:

- Share results and/or information on projects related to agri-fibre.
- Tour ARC facilities related to structural and composite panels and pulp and paper making pilot.

### *Properties and Uses of Agri-Fiber Pulps for Paper Making – W. Chiste ARC*

- Paper "a felted sheet formed on a fine screen from a water suspension of fibers."
- Two fiber types – long (i.e. softwood, flax); short (hardwood, cereal straw, hurds, shives).
- Paper makers primarily interested in bast fibers because of their strength.
- Comparison of flax/softwood fiber:

| | Flax | Softwood |
|---|---|---|
| Cellulose Content | 76 to 79% | 53 to 62% |
| Lignan Content | 10 to 15% | 26 – 34% |
| Ash Content | 2 to 5% | <0.5% |
| Fiber Length | 30 mm | 2.7 to 4.6 mm |
| Fiber Diameter | 20 um | 32 to 45 um |

- Chemical and mechanical pulping are two major pulping processes.
- Bast fiber – bleached chemical pulp; post refined (mechanical) to develop maximum strength; blended to produce currency, cigarette paper, etc.
- ARC pulp and paper pilot plant provides opportunities for more research.

### *Hydrogen Peroxide Bleaching of Agrifibers – G. Pan, ARC*

- Hydrogen peroxide – widely used bleach chemical; relatively cheap and environmentally benign.

- Agrifibers: use a simplified composition of peroxide bleach; need a pretreatment to increase bleaching efficiency.
- At 40% $H_2O_2$ (on dry weight of fibers) flax and hemp have a brightness of approximately 80% to ISO - at acceptable costs.

## *Research on Hemp at U of A – N. Kerry, U of A*

- Hemp research to determine what factors affect fiber quality.
- Must decorticate – field retting in Alberta not possible.
- Tank setting utilized (34° 3 to 4 days) then dried and fiber separated from hurds using rollers; combing, etc.
- Fiber quality assessed by measuring mechanical properties.
- Gaps: fiber processing – equipment and research; fiber application.
- Hemp/flax very similar with hemp, producing slightly coarser material than linen.

## *The Potential for Agricultural Fibers – K. Domier, U of A*

- 1999 production of flax straw approximately 1,250,000 tonnes of which 15 to 20% purchased by two companies. DuraFibre utilized another 50 to 60,000 tonnes leaving 1 M tonnes in the field.
- Economic value of industrial grade oilseed flax fiber is $500 to 1,500 depending upon cleanliness.
- Europe, enhanced interest in natural fibers.
- Auto industry in North America using Saskatchewan flax.
- Fiber flax being re-introduced in North America in Quebec and South Carolina.
- No textile plants in North America to process long line flax.
- Hemp can be grown in Canada since 1997 and is grown for seed for fiber or both..
- Research with hemp fiber under way at the U of A.

## *Development of Structural Panels from Split Straw – W. Wasylciw, ARC*

- Currently 21 straw panel board projects operating, under construction or in development in North America involving manufacture of particle board or medium density fiber board.
- Advantages: binder costs competitive; better surface attainable; production costs (except resin) are lower than wood based.
- Technology barrier: to open straw tube while maintaining as much length as possible.
- Production: screening, blending, forming an depressing same as wood.
- Product proven on pilot scale, seeking commercial partners.

### *Utilization of Hemp in Composite Panel Products – W. Wasylciw, ARC*

- Looked at hemp utilization in three projects – analysis, prototypes, specialized process.
- Hemp fibers prove difficult to use in panels, hurds are suitable.

### *Fiber Chemistry and Characterization of Canadian Ag Residues and their Pulps*

- Papers were disseminated.

# Appendix G

# Definitions and/or Descriptions of Some Flax and Fiber Related Terms

## Definitions and/or Descriptions of Some Flax and Fiber Related Terms

**Abaca** – The abaca plant looks much like a banana plant but it has high fiber content and only small amounts of fruit. The long strong fibers are found mainly in the trunk and main rib of the leaves. Abaca needs particular environmental conditions within the moist tropics to produce high quality fiber. For centuries most of the best abaca has come from the Philippines. Since the processed fibers look similar to long hemp fibers and since Manila is the major port of the Philippines, abaca is also referred to as "Manila hemp". Abaca is used by itself or in a blend with other fibers for specialty paper products (e.g., tea bags, cigarette fibers), for ropes and mats, and for general packing material.

**Acetylation** – Refers to several combined chemical and physical processes which can be used to permanently swell cellulose based fibers (e.g., flax, jute, hemp) so that they no longer swell when they become moist or shrink when they become dry. In composite materials made from plastic and cellulose-based fibers or cement and cellulose based fibers, it is important to stop the fibers from swelling and shrinking so that the composite structure does not weaken over time. Acetylation would most likely need to be done if the composite material was used in an application that was often exposed to liquids (e.g., sewer pipes, artificial wood for outdoor use), however, fibers would not have to be acetylated if the composite was used in applications that were normally not exposed to wide ranges of moisture levels (e.g., car dashboards).

**Bast Fibers** – These refer to commercially valuable plant fibers which are found in the stems of plants as opposed to commercially valuable fibers which are found in the leaves (e.g., sisal, abaca) or in the seed pods (e.g., cotton, coir). Bast fibers are composed mainly of cellulose and hence form a subset of fibers within the whole set of cellulosic fibers, which include such fibers as those from wood, and from cotton. The most commonly used bast fibers are jute, flax, kenaf, hemp and ramie.

**Breaking** – Traditionally after the seeds were removed from dry, retted flax straw, the flax was "broken" by passing it through a crimping device, by hitting it at right angles with a smooth board or by pounding it with a large wooden mallet. The purpose of this "breaking" was to break the brittle non-fiber part of the stem called shives into small pieces without doing damage to the flexible fibers that surround the stem. The smaller the shives, the easier they are to remove from the fibers. In modern flax mills, flax straw is broken by passing the straw between rapidly rotating fluted rollers that mesh together with neighboring rollers.

**Coir** – The hard brown coconut that consumers see in stores in North America is actually formed high up in the coconut tree inside a larger green pod that is packed with coarse, short, strong brown fibers called coir. When coconuts are harvested the pods are opened and the hard round nuts are taken out of the surrounding fibers. The remaining green pods with the coir are submerged in water until the coir can be easily separated from the outer skin of the pod. The coir is the dried and cleaned and used in products like door mats, ropes, brushes and brooms, mattress stuffing, hanging baskets for plants, potting mixes and general packing material.

**Cottonized Flax** – Over 90% of the world's spinning equipment are designed to quickly and effectively spin fibers that have the length and diameter of cotton fibers. This is referred to as the "cotton" system. No other spinning system is as productive or cost-effective as the cotton system. By coincidence, the ultimate fibers of flax have approximately the same length and diameter of cotton, however, the ultimate fibers of flax are normally glued with pectins and lignins into long line or tow fibers. Several processes have been developed to break the tow or long line into ultimate fibers so that the ultimate flax fibers can be spun and/or blended easily using the cotton system. The process of breaking down long line or fibers into ultimate fibers is called cottonization and the product is called cottonized flax. Flax has traditionally been cottonized using mechanical systems (i.e., mechanical cottonization) but it can also be done using enzymes, steam explosion and ultra-sound.

**Decorticating** – Sometimes bast fibers are only partly retted or not retted at all before the stems are put through a series of rollers, hammers and/or shakers to extract the fibers. This process is called decorticating and it is used to replace the processes of breaking, scutching and hackling but it generally produces a very coarse fiber that is not used in textiles but is rather used for industrial purposes like paper making and geotextiles. Decorticating is generally much cheaper than breaking, scutching and hackling but the quality and value of the resultant fibers is not as high.

**Geotextiles** – Textile products that are deliberately placed in contact with the ground are often referred to as geotextiles. Such geotextiles are often in the form of mats of natural or synthetic fibers and/or sheets of synthetic material. They are often used to prevent soil erosion on the sides of newly constructed road embankments, building sites, reservoirs, tailings ponds, etc. They are also used in agricultural applications such as mulch material for horticultural and tree crops and may be impregnated with seeds for products like "roll-out" lawns and playgrounds. Natural fibers are preferred in geotextile applications where it is desired to have the geotextile decompose after several years (e.g., after the grass is established on the road embankment) whereas synthetic fibers are preferred where it is desired to have the geotextile last for many years (e.g., as a lining for a tailings pond).

**Hackling** – After the flax fibers are scutched, the fibers need to be combed to straighten the fibers, to clean any remaining shives out of the fibers and to remove fibers, which are weak or short. This is done by combing the fibers with a succession of finer and finer combs in a process called hackling.

**Hurds** – The hurds are the non-fiber, parts of the stems of the hemp plant.

**Kenaf** – The kenaf plant grows best in warm temperate and warm tropical parts of the world (e.g., India, China, Texas). It produces fibers in its stems and hence is a bast fiber plant. It can reach heights of two to four meters and has long slender stems that look similar to jute. Kenaf fibers are very short relative to other bast fibers and hence kenaf is usually used as a source of fiber for pulping and as a replacement for fiberglass, however, some countries also use it to make coarse jute-like bags for carrying products like grain and coffee beans.

**Long Line** – These are flax or hemp fibers which are used to spin and weave 100% pure linen and hemp fabrics. Most long line fiber processing lines can only handle long line fibers that are longer than half a meter in length and shorter than one meter. Long line fibers are composed of bundles of "ultimate" fibers which are glued by pectins side by side and end to end to make a fiber "bundle" which looks like a very thing yarn to the naked eye.

**Ramie** – Ramie plants are perennial shrubs one to two meters in height with long slender stalks. Stalks are cut off several times a year and the fibers are extracted using a combination of mechanical and chemical systems. Unlike other bast fibers, ramie fibers are not released by retting alone and hence chemicals must be used. This results in long bleached fibers with high strength and luster. Ramie fibers are said to be the strongest bast fibers (three times as strong as hemp) but they are relatively expensive to produce and are used mostly for blending with other fibers in textiles to give a silk or linen look. Most ramie is grown in China, the Philippines and Brazil.

**Retting** – The bast fibers of plants form part of what the layman might called the "inner bark" of plant stems. These fibers are tightly held within the plant by glue-like substances called pectins and lignins. Before clean bast fibers can be easily removed from the stems, the pectins and lignins must be softened and/or removed. The most common and cheapest method of doing this is to allow microorganisms to grow on the surface of the stems. As they grow, these organisms dissolve the pectins and lignins and hence make it easier to remove the fibers from the stems. However, if the straw is allowed to ret for too long a period, the organisms will also start to dissolve the fibers and hence the fibers will get weaker. Retting can be done in several ways. These include placing the straw in cold water (cold water or river or bog retting), placing it in warm water (warm water retting or tank retting) or by placing it in a thin layer next to the ground (dew or field retting). Straw can also be placed in mixtures of chemicals and water (chemical retting). In recent decades, people have searched for alternative ways to remove the pectins and lignins without retting. The most common of these methods include treating the straw with enzymes (sometimes called enzymatic retting), steam explosion (sometimes called flash hydrolysis) and ultra-sound.

**Scutching** – After flax straw is broken and the straw has been shaken to remove the loose shives, there are generally some shives still stuck to or tangled within fibers. The scutching process attempts to scrape loose and/or disentangle this remaining shives from the fiber by stroking the fibers in a manner similar to combing fibers with a comb that has no teeth. In modern flax straw mills this is done by having straw which has already been broken and shaken, pass between rotating beaters or turbines which have paddles or arms that beat and scrape the remaining shives from the fibers.

**Shives** – The shives are the non-fiber parts of the stems of flax plants.

**Sliver** – After bast fibers are hackled, they are arranged in a continuous ribbon-like band of fibers called a sliver. This sliver can then be further combed, blended and made narrower and more consistent in size in preparation for spinning.

**Sisal** – The sisal plant is a type of succulent that grows best in the dry tropics in countries like Mexico, Brazil and Tanzania. It looks somewhat like a giant Aloe Vera with straight stiff leaves about one meter in length growing directly out of the central stem. The lower, more mature leaves are harvested periodically and put through a series of rollers to extract the stiff, strong, coarse fibers that are then dried in the sun. Sisal fibers are cheap and strong but cannot be easily divided into finer fibers that would be suitable for textiles. Sisal is mostly commonly used for baler twine, bags, ropes, mats, tea bags and as reinforcement in some rubber products.

**Tow** – In bast fiber processing, there are only two main types of fiber; the long straight strong fibers called long line and the short, bent and/or weak fibers called tow. During processing, tow fibers are produced at each stage of fiber preparation. Hence there is breaker tow (usually coarse short fibers with lots of shives), scutching tow (medium coarse to medium fine short fibers with some shives) and hackled tow (short fine strong fibers with few or no shives). There is a wide range of prices paid for tow because tow can have a wide range of properties. In general breaker tow is the cheapest and hackled tow is the most expensive.

**Ultimate Fiber** – The ultimate fiber is the smallest easily separated "bast" fiber in flax or hemp. The ultimate fibers of flax are roughly the length and width of a cotton fiber; the ultimate fibers of hemp are slightly thicker and longer than those of flax. To the naked eye, an ultimate fiber would be like the split end of a human hair.